2.4 *Command And Communication Support System*

2.4.1 Transparent Data System

Figures 2.43 through 2.47 illustrate the transparent data system available to the customer through HH. The figures present the command, low-rate and medium rate data flows. The data communications interface generally remains unchanged from the customer's point of view independent of whether the payload is at the customer's facility, at the integration facility, or during flight operations. Some ground data processing functions may have optional service charges for reimbursable customers. Contact the Project Office for details.

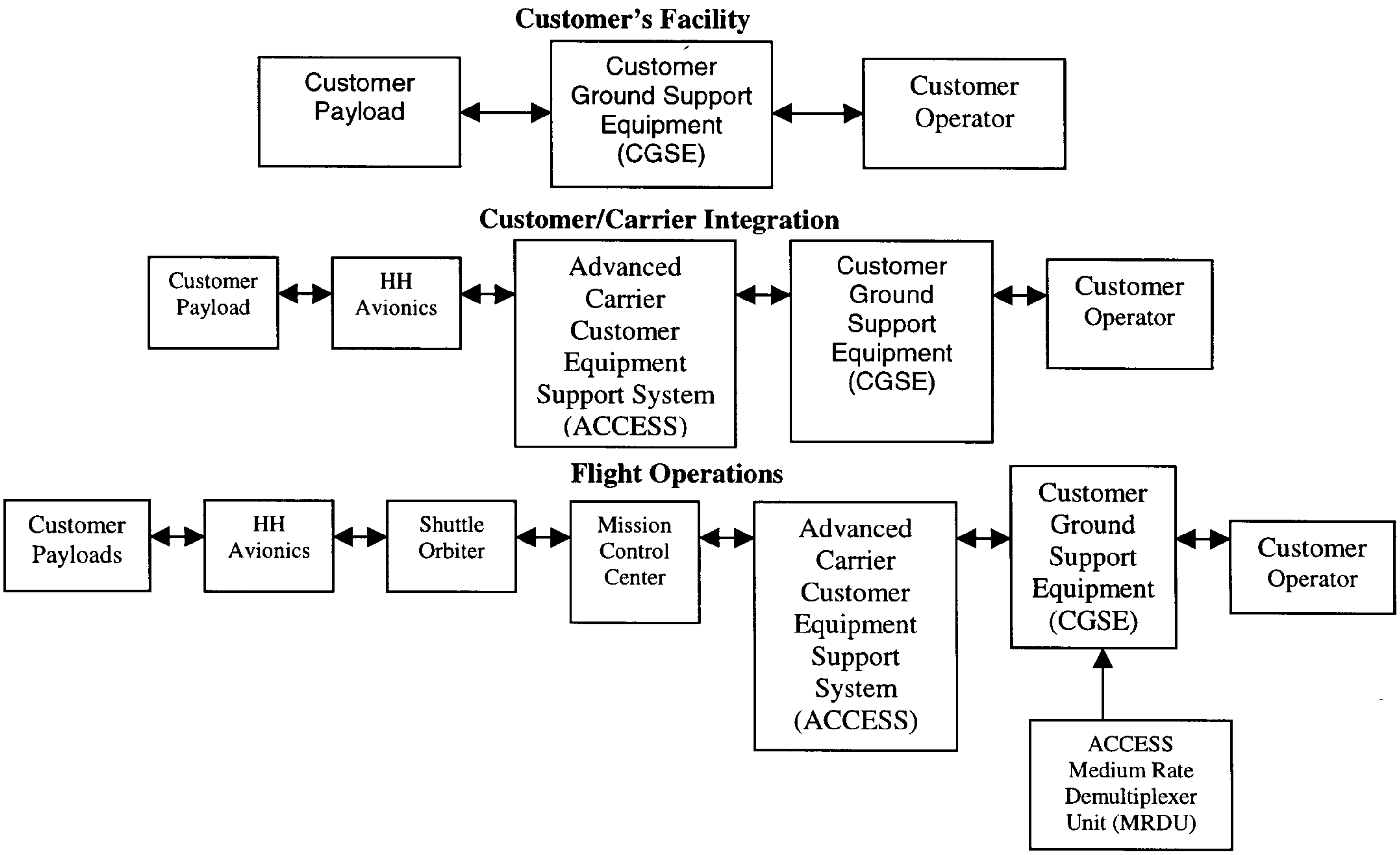


FIGURE 2.43 HITCHHIKER TRANSPARENT DATA SYSTEM

Hitchhiker Command Flow

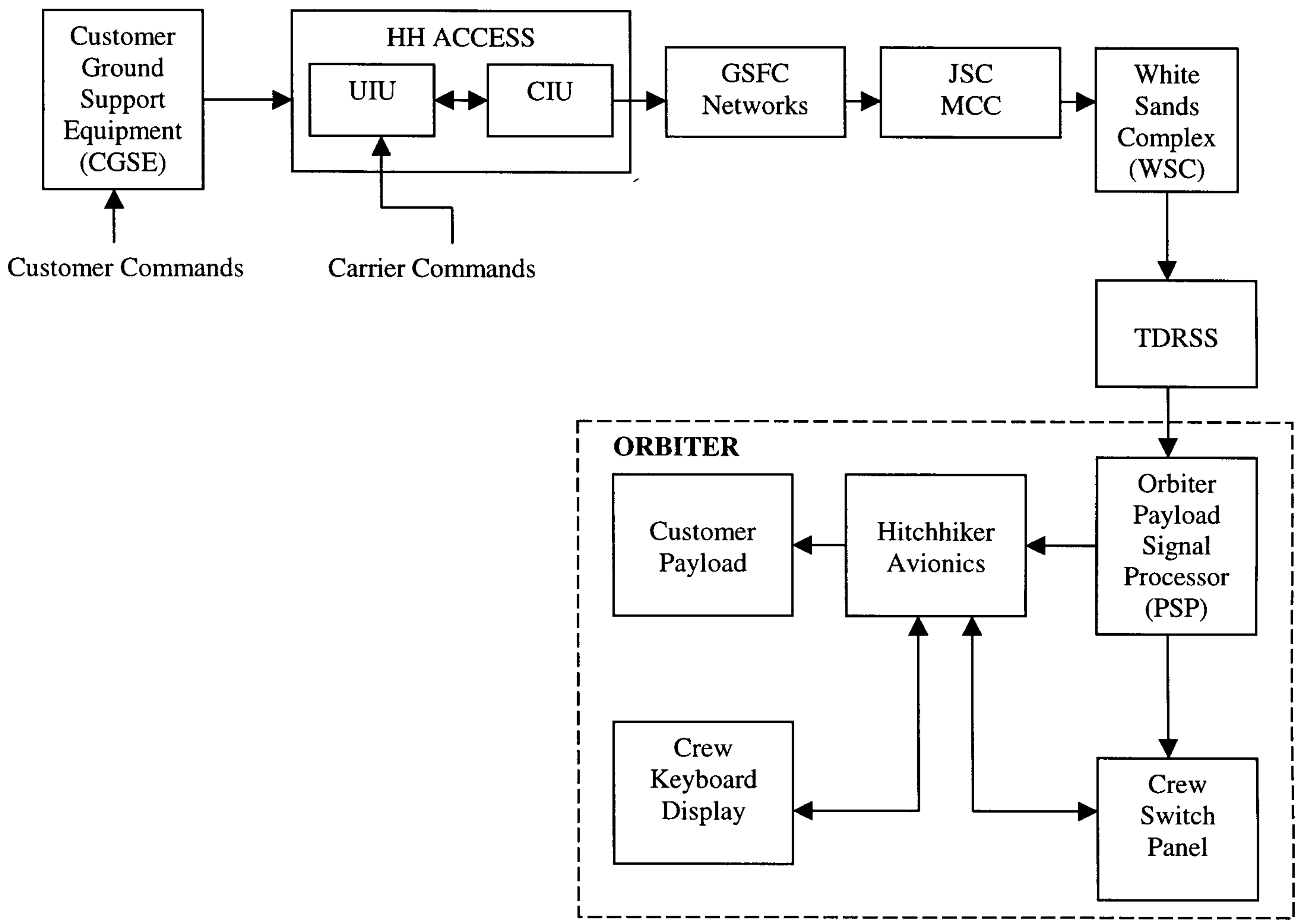


FIGURE 2.44 HITCHHIKER COMMAND FLOW

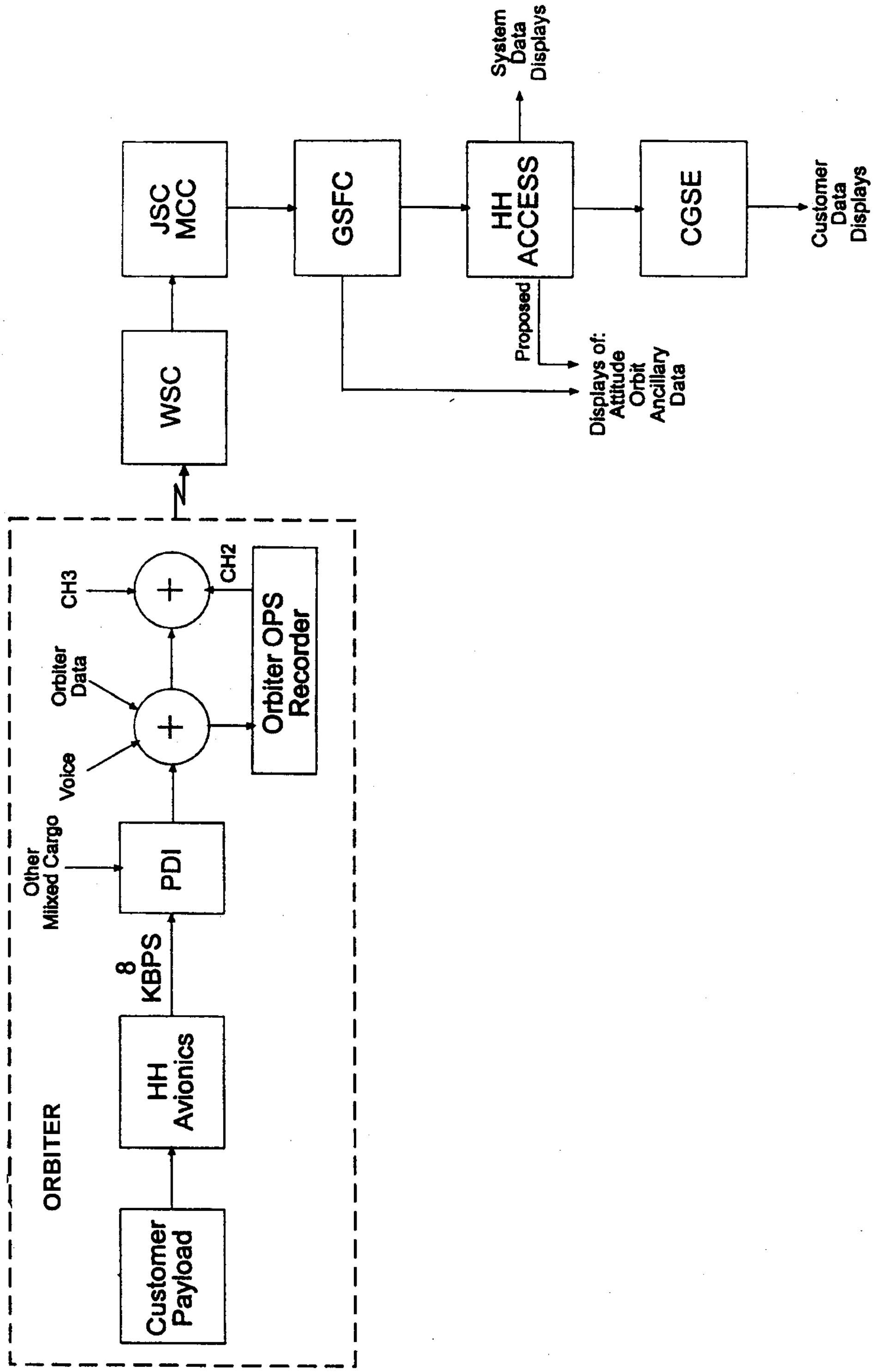


FIGURE 2.45 HITCHHIKER LOW RATE DATA FLOW

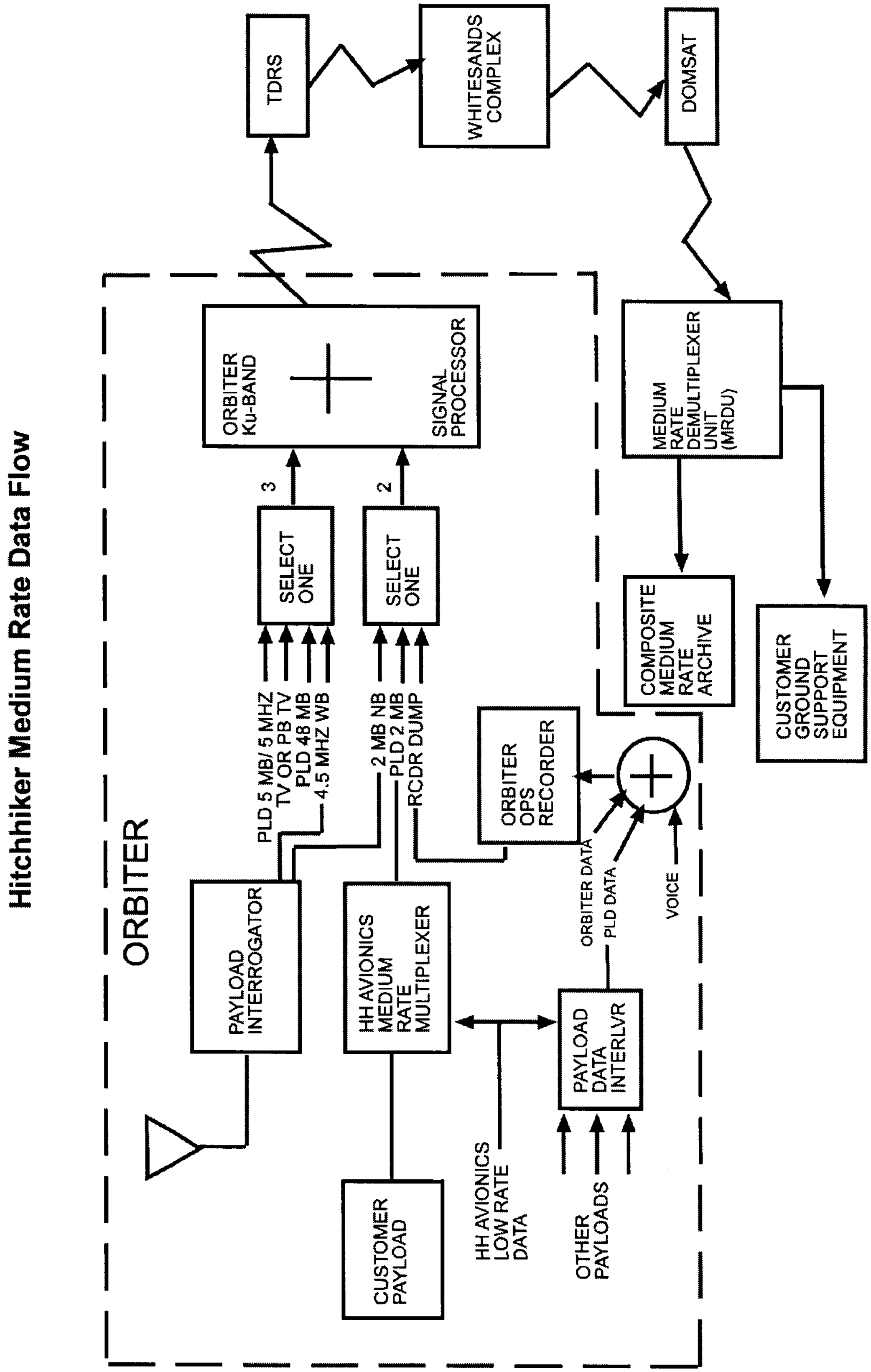


FIGURE 2.46 HITCHHIKER MEDIUM RATE DATA FLOW

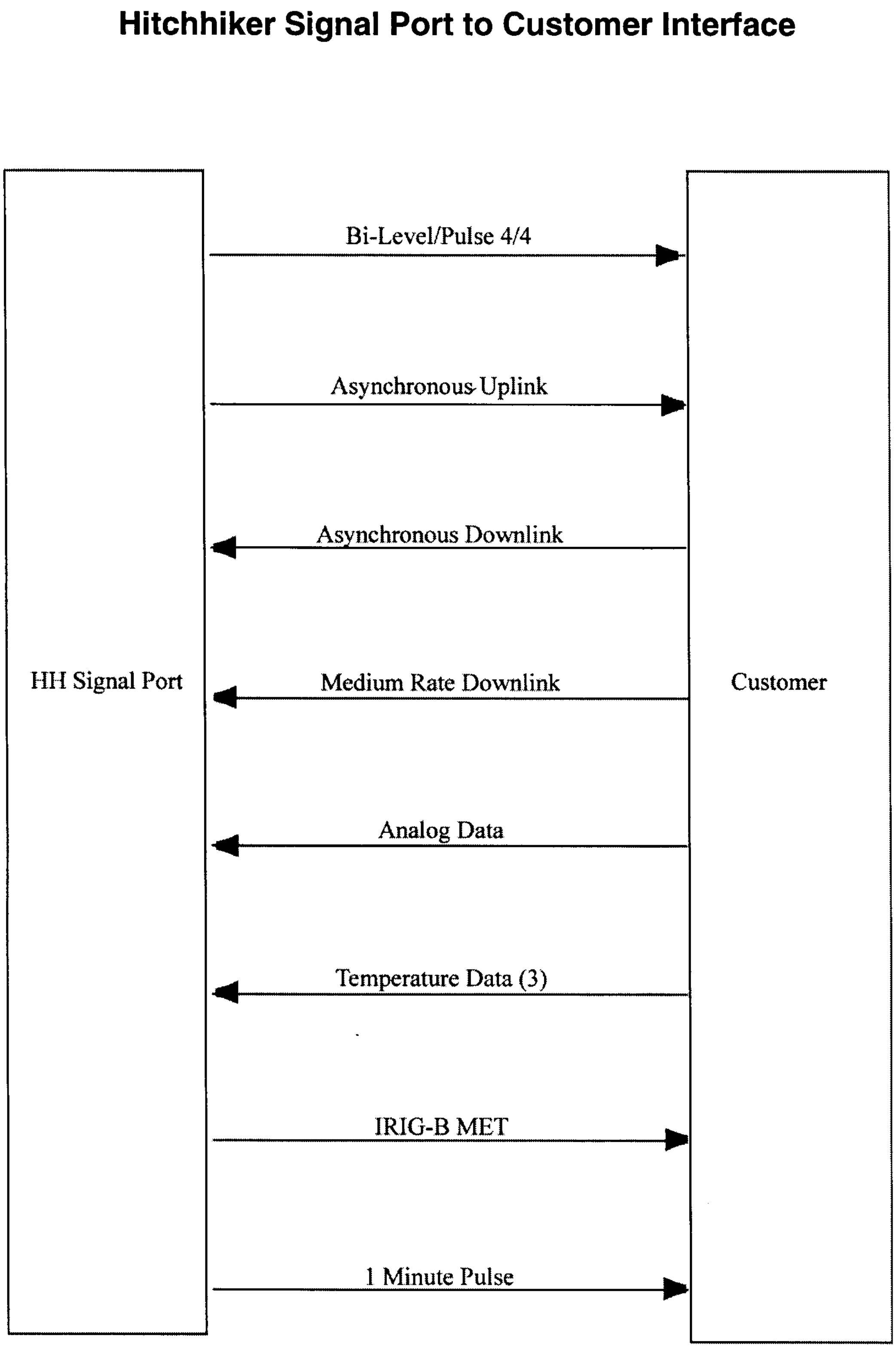
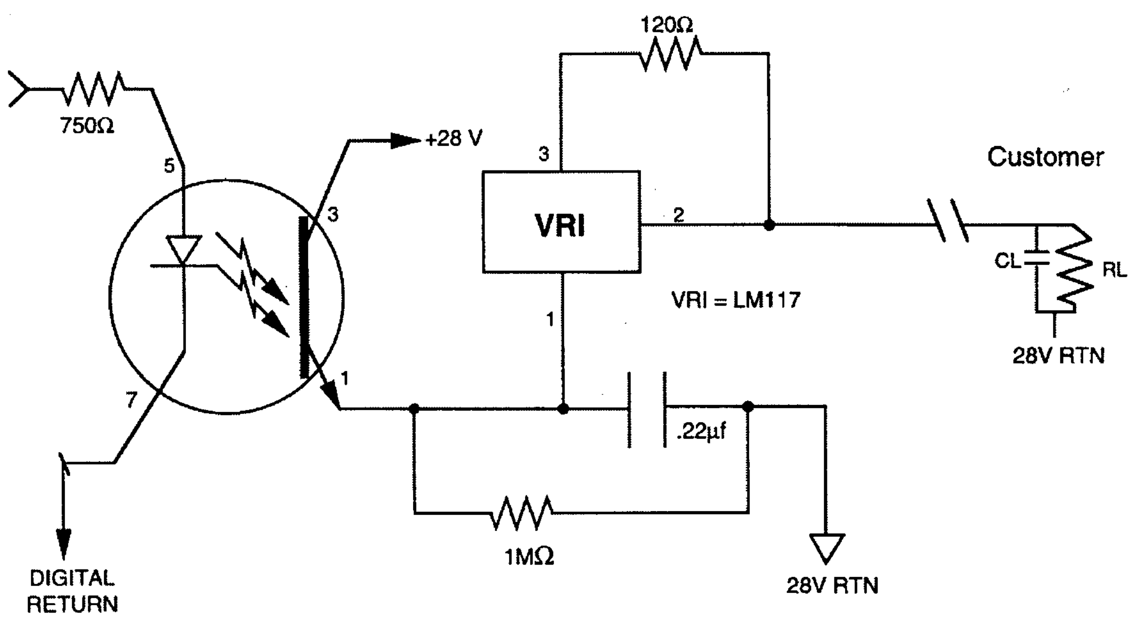


FIGURE 2.47 HITCHHIKER SIGNAL PORT TO CUSTOMER INTERFACE

2.4.2 Bi-Level Command System

Signals that traverse the bi-level command interface may be set to ØV (false) or +28V (+19.5 to +32V) (true), or may be pulsed from false to true and back to false. There are four bi-level signals per interface. Figure 2.48 illustrates the customer bi-level command interface while Figures 2.49 and 2.50 show the command formats. Only one of the four signals may be affected by any one command. Bi-level commands can be sent either via ACCESS or CGSE.

CUSTOMER BI-LEVEL COMMAND INTERFACE



RL = 3.2K OHMS Min. (Customer Power On or Off)
RL = 10K Ohms Max, (Source 10ma Max; Sink 0)
CL = 1500 PF Max,
VT = 26 +/- 7V
VF = 1.5 +/- 1.5V
VNOISE = 1.6 V P-P (Max.)
TR = TF= 10 Microsec(Min)
TR = TF= 100 Microsec (Max)
T1 = 50 +/- 30 MS (Pulse Mode)

FIGURE 2.48 CUSTOMER BI-LEVEL COMMAND INTERFACE

Customer Message Format for 28 Volt Bi-Level Commands

1	2	3	4	5	6	7	8
1	1	1	0	0	1	0	1
0	0	0	0	0	0	0	1
CID				0	0	1	1
S4	S3	S2	S1	R4	R3	R2	R1
CHECK							

S1-S4 Set Bi-Level 1-4 True = 28V
R1-R4 Reset Bi-Level 1-4 to False = 0V
RN and SN Simultaneously True = Error, No Action
Type = 3, Byte Count = 1. Any Bi-Level Command Lines Not Selected by Ones in SN, RN Will Not Be Affected

Customer Line Numbers

Only One Bi-Level Line May be Set/Reset by a Single Command.

Note: 28 volt bi-level and 28 volt pulse commands use the same 4 wires per customer interface (17,18,19,20).

FIGURE 2.49 CUSTOMER MESSAGE FORMAT FOR 28 VOLT BI-LEVEL COMMANDS

Customer Message Format For 28 Volt Pulse Commands

1	2	3	4	5	6	7	8
1	1	1	0	0	1	0	1
0	0	0	0	0	0	0	1
CID				0	1	0	1
0	0	0	0	P4	P3	P2	P1
CHECK							

P1 -P4+ 1 PULSE BI-LEVEL LINE 1-4 SETS SELECTED BI-LEVEL LINES(S) ON CUSTOMER PORT CID TO TRUE (+28V) FOR 20- 80 MILLISECONDS THEN RETURNS LINE TO FALSE (OV). STATES OF ANY BI-LEVEL COMMAND LINES NOT SELECTED BY ONES ARE NOT AFFECTED. CUSTOMERS DESIGN MUST BE CAPABLE OF WITHSTANDING CONTINUOUS +28V ON ANY BI-LEVEL LINE WITH NO DAMAGE IN EVENT OF SOFTWARE FAILURE. TYPE =5, BYTE COUNT =1

CUSTOMER LINE NUMBERS

ONLY ONE LINE MAY BE PULSED BY A SINGLE COMMAND.

NOTE: 28 VOLT PULSE AND 28 VOLT BI-LEVEL COMMAND USE
THE SAME 4 WIRES PER CUSTOMER INTERFACE (17,18, 19, 20)

FIGURE 2.50 CUSTOMER MESSAGE FORMAT FOR 28 VOLT PULSE COMMANDS

2.4.3 Asynchronous Uplink

The asynchronous uplink is used to transmit customer asynchronous command messages and Mission Elapsed Time (MET) messages to the payload. All commands issued by the CGSE have the general format shown in Figure 2.51

The customer message format for asynchronous commands is shown in Figure 2.52. The format of the asynchronous MET message is shown in Figure 2.53. The format of the synchronize to MET command is shown on Figure 2.54 One receive data (RD) signal is available through each HH port.

The interface operates at 1200 baud asynchronous data rate. The signal format is shown in Figure 2.55 where each signal contains one start bit, eight data bits (no parity), and one stop bit. The uplink messages may originate from the ACCESS or from CGSE. The transport delay between CGSE and the customer's payload is nominally 2 to 20 seconds. The transport delays are due to latencies introduced by the number of CGSEs issuing commands, the networks, JSC Mission Control Center (MCC) and uplink delays. The delay does not account for retrying a command because of command uplink failure.

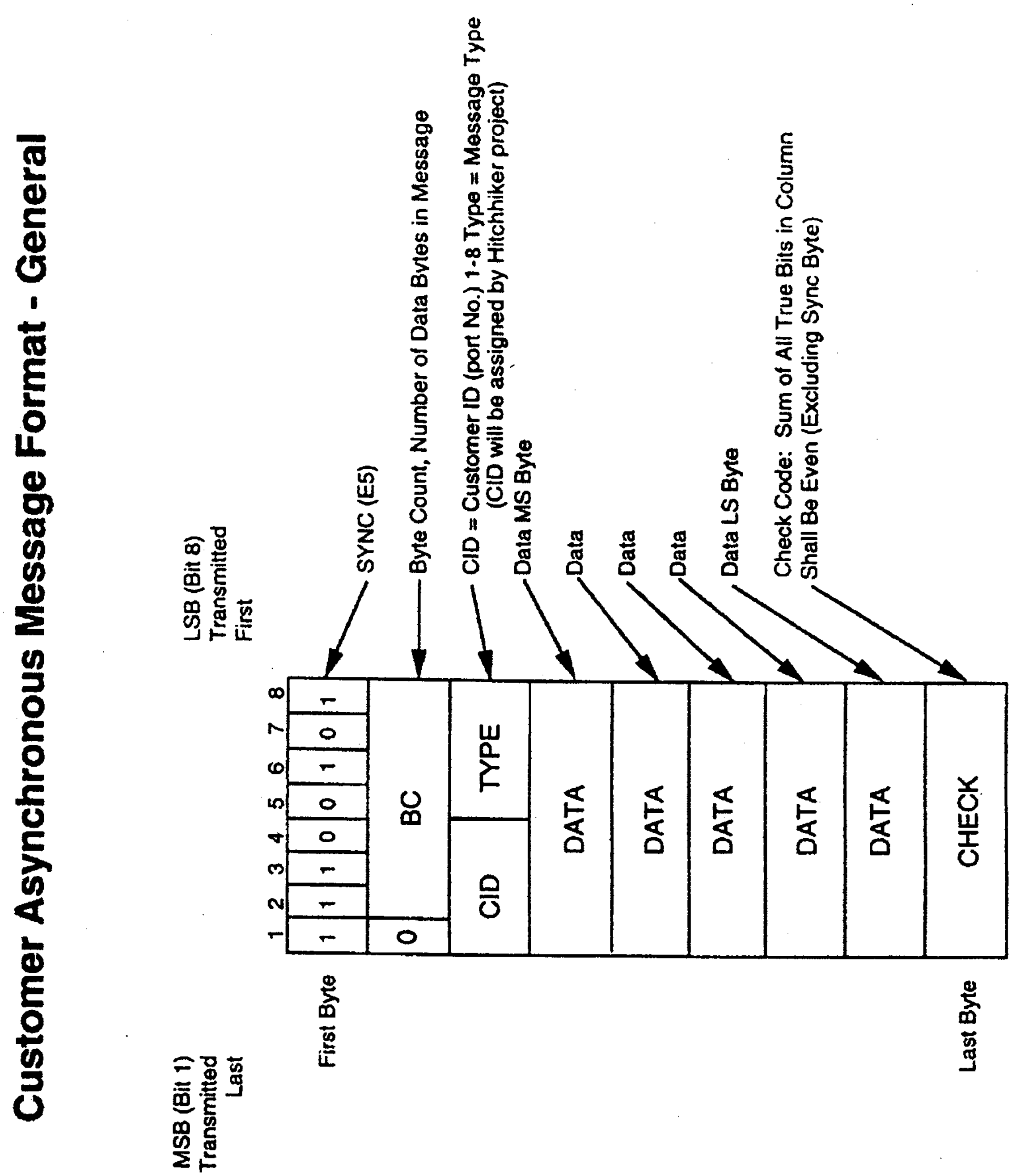
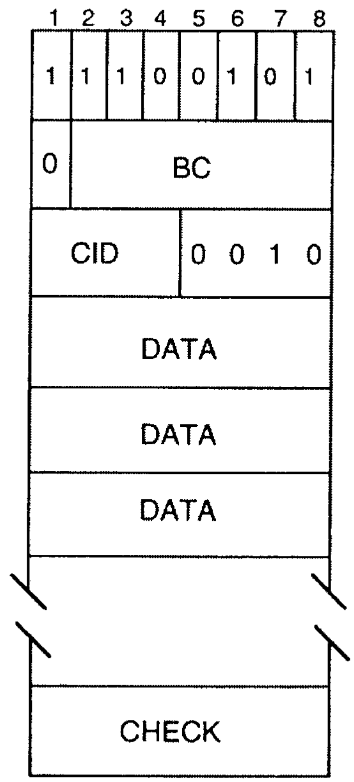


FIGURE 2.51 CUSTOMER ASYNCHRONOUS MESSAGE FORMAT – GENERAL

Customer Message Format for Asynchronous Commands



Entire Message Including Sync and
Check Bytes to be Transmitted to
Customer Port CID
RD Asynchronous on Pins 21 & 22.
Type = 2

Format of CGSE Message Identical

FIGURE 2.52 CUSTOMER FORMAT FOR ASYNCHRONOUS COMMANDS

Customer Message Format For MET

1	2	3	4	5	6	7	8
1	1	1	0	0	1	0	1
0	0	0	0	0	1	0	0
CID				0	1	0	0
D1	D2	D3	D4	D5	D6	D7	D8
D9	D10	H1	H2	H3	H4	H5	H6
0	M1	M2	M3	M4	M5	M6	M7
0	S1	S2	S3	S4	S5	S6	S7
CHECK							

D1-200 DAYS	H1-20 HOURS	M1-40 MIN	S1-40 SEC
D2 -100	H2-10	M2-20	S2-20
D3-80	H3-8	M3-10	S3-10
D4-40	H4-4	M4-8	S4-8
D5-20	H5-2	M5-4	S5-4
D6-10	H6-1	M6-2	S6-2
D7-8		M7-1	S7-1
D8-4			
D9-2			
D10-1			

4 BYTES

Command to be transmitted to customer payload asynchronous port at a time other than MET second 1 or 59. The 4 bytes of time data will be filled in by the SPOC avionics using Orbiter supplied time. When sent by the customer, the 4 bytes are "don't care" and may contain anything. CGSE command with dummy data initiates transmission of MET command, type=4.

FIGURE 2.53 CUSTOMER MESSAGE FOR MET

Customer Message Format for Synchronized MET

1	2	3	4	5	6	7	8	
1	1	1	0	0	1	0	1	
0	0	0	0	0	1	0	0	Byte Count
CID				0	1	1	0	Subcommand Type 6
D1	D2	D3	D4	D5	D6	D7	D8	
D9	D10	H1	H2	H3	H4	H5	H6	
0	M1	M2	M3	M4	M5	M6	M7	
0	S0	S0	S0	S0	S0	S0	S0	
CHECK								Checksum

Notes:

1. Unless MET is within ±5 seconds of the new minute, the next minute represented by the minute pulse is sent via the RS-422 Asynchronous Interface.
   If MET is within 5 seconds of the new minute, then the time sent to the customer is the <u>NEXT</u> minute, not the upcoming minute.

2. This command is not implemented in some HH avionics. Check with HH project for availability.

FIGURE 2.54 CUSTOMER MESSAGE FORMAT FOR SYNCHRONIZED MET

Customer Asynchronous RD Interface

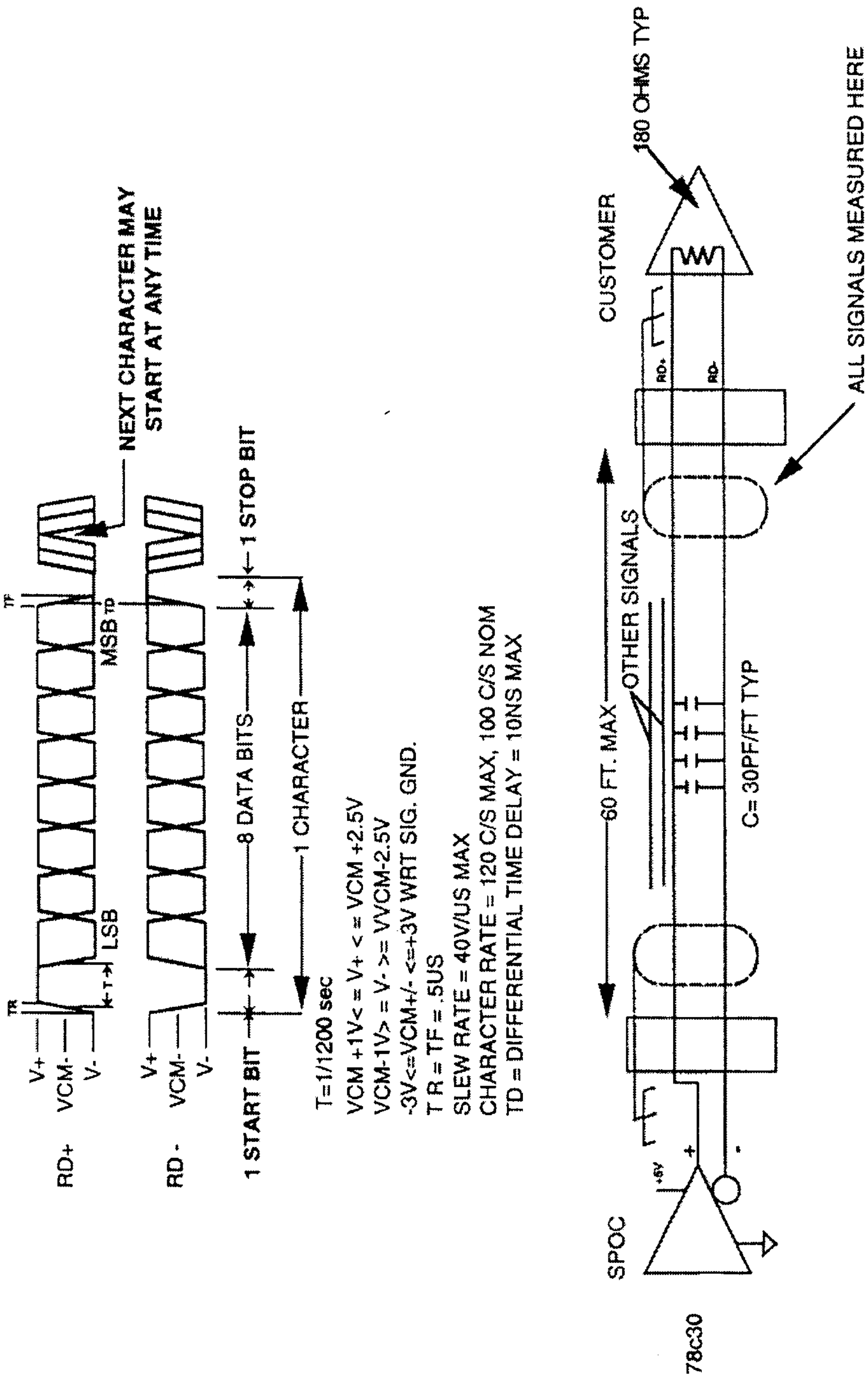


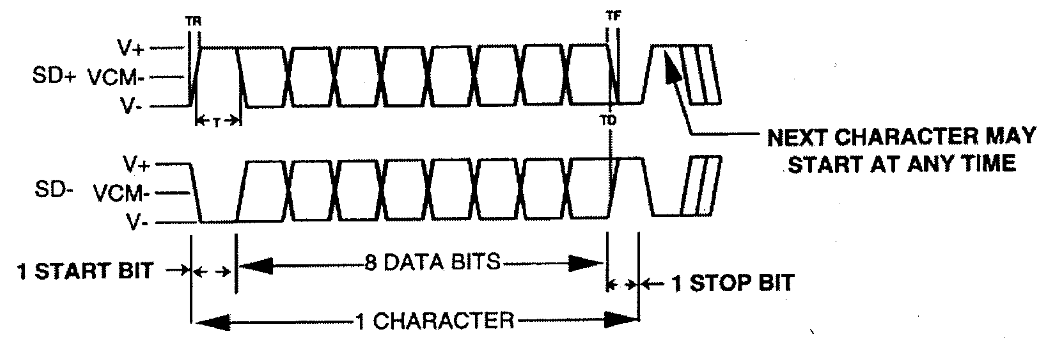
FIGURE 2.55 CUSTOMER ASYNCHRONOUS RD INTERFACE

2.4.4 Asynchronous Downlink

One Asynchronous Send Data (SD) signal per interface that operates at 1200-baud asynchronous and has a similar message pattern (one bit start, 8 data bits, and one stop bit) as the uplink interface is available through the HH interface. (See Figure 2.56).

The downlink can support continuous 1200-baud transmission which will be routed to the customer's GSE via the ACCESS to CGSE interfaces. Downlink messages do not have a format requirement. Nominally, the transport delay between customer payload and customer GSE is 5 to 15 seconds. The standard HH avionics arrangement can simultaneously downlink any 5 of the 8 available asynchronous downlink channels. These channels are selectable via ground system commands from the ACCESS.

Customer Asynchronous SD Interface



VCM +1V< = V+ < = VCM +2.5V
VCM-1V> = V- >= VVCM-2.5V
-3V<=VCM+/- <=+3V WRT SIG. GND.
T = .8333 MS (1200 BAUD)
VCM+ = VCM- (+/-50MV)
TR = TF = 1µS MAX   INPUT Z = 130 OHMS +/-10%
TD = DIFFERENTIAL TIME DELAY = 5NS MAX

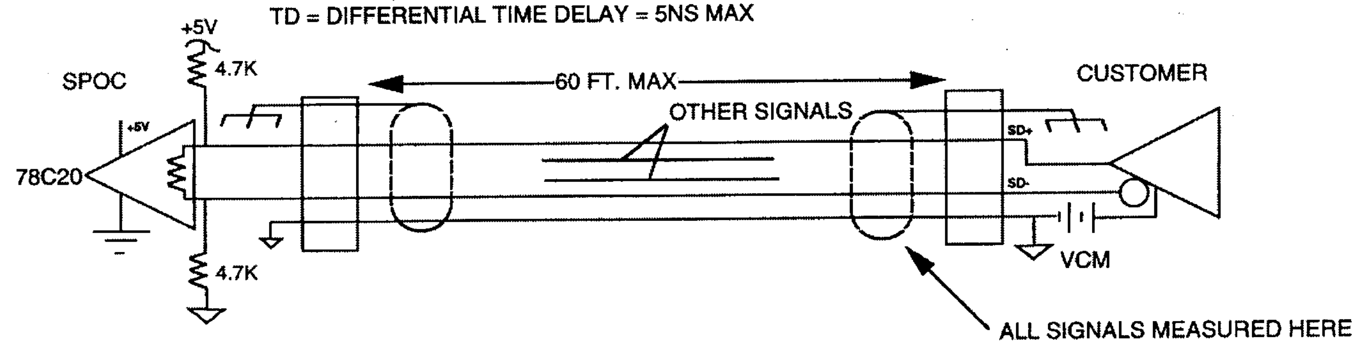


FIGURE 2.56 CUSTOMER ASYNCHRONOUS SD INTERFACE

2.4.5 Medium-Rate Ku-Band Downlink

The carrier contains a Medium-rate Multiplexer (MRM) capable of multiplexing up to six simultaneous customer-provided serial-bit non-return to zero (NRZ) data signals into a single serial 2Mb/s bit-stream for transmission via channel 2 of the Orbiter Ku-band Tracking and Data Relay Satellite System (TDRSS) signal processing system. The combined simultaneous input rate to the MRM from all HH experiments cannot exceed 1.4 Mb/s. This effectively limits customer downlink rates if the MRM is accepting data from more than one source. As previously shown in Figure 2.45, channel 2 is not available for exclusive use of HH data but is shared with dumping of the Orbiter's tape recorder and the payload interrogator. In addition, use of the medium-rate system requires the TDRSS as well as deployment and pointing of a steerable antenna on the Orbiter which cannot be used in certain attitudes or orbit positions. In general, Ku-band medium-rate service should be available approximately 50 percent of the time during a typical flight.

Medium-rate data accommodations will be allocated by the SSPP on a case-by-case basis. This allocation will depend on several factors, including experiment data rate, mission timeline, and the requirements of other co-manifested experiments. The maximum data rate per user channel is 880 kbps. If conflicts exist between several medium-rate users, then medium-rate data output must be controllable via CGSE ground command.

Each customer-supplied input data stream must be continuous and stable within 1 percent of its assigned data rate during the customer's data-take periods. If the customer's data is discontinuous or event-oriented, the customer may elect to have the clock stop between periods of valid data, or may elect to transmit continuous clock but discontinue transmitting valid data.

It is recommended that each valid period be preceded by at least 4 data frames of leader telemetry prior to the first frame of required data. This is needed in order to ensure that the ACCESS ground data system has sufficient time to sync on the composite downlink signal during mission. Each data period must be followed by at least 66 bytes of clock to flush the customer data buffer in the MRM.

Customer data during valid data periods must consist of a continuous series of data frames each containing a fixed integral multiple of 8 bits but no more than 8,192 bits. Each data frame must contain a fixed synchronization pattern of at least 24 bits to be specified by the customer. The pattern FAF320 (hexadecimal, most significant bit and byte first) is recommended but may be customer selected. The remaining format of the data frames can be determined by the customer as desired; however, the following considerations should be taken into account. Each data frame should contain a frame number that does not repeat for at least 256 frames, as well as time information adequate for the customer's needs; it should also contain provision for error detection if necessary to meet the customer' goals.

During testing and flight operations, the Medium Rate Demultiplexer Unit (MRDU), referenced in Figure 2.46, will decommutate the multiplexed signal and regenerate the customer's clock and data for use by the CGSE. This data interface is shown in Table 2.12. The clock will generally be at a slightly higher bit rate than the onboard customer supplied clock. The ground clock and data will stop momentarily periodically to equalize the average data rate.

The data bit error rate is expected to be generally no worse than 10^{-5}; however, there will be periods of dropout and deteriorated data especially near the ends of TDRSS coverage periods. The data delay will be several hundred bytes plus approximately 2 seconds. The CGSE must be designed to obtain and maintain synchronization and otherwise operate in a satisfactory manner under these conditions.

The electrical interfaces and timing for the medium-rate system are shown in Figures 2.57, 2.58 and 2.59. Data return on the ground can be either by NRZ-L serial data and clock interface identical to Figures 2.58 and 2.59 or post mission by Compact Disc (CD). The CD format is shown in Appendix C and will be frame synchronized data sets if the customer uses a fixed-frame length. GSFC engineers can assist customers in the design of prospective medium rate (MR) telemetry formats. Again, the customer's medium-rate ground data interface is shown in Table 2.12.

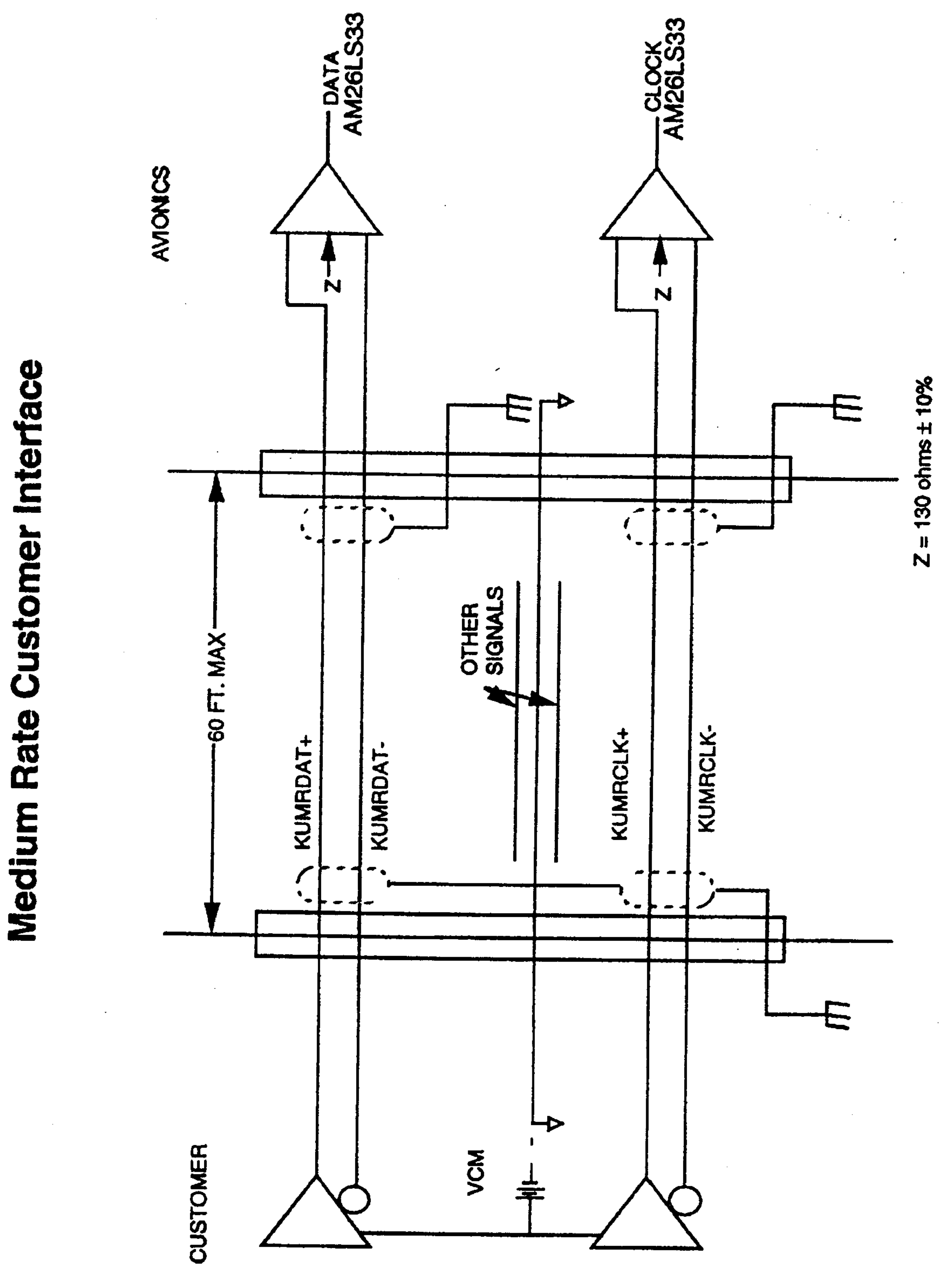
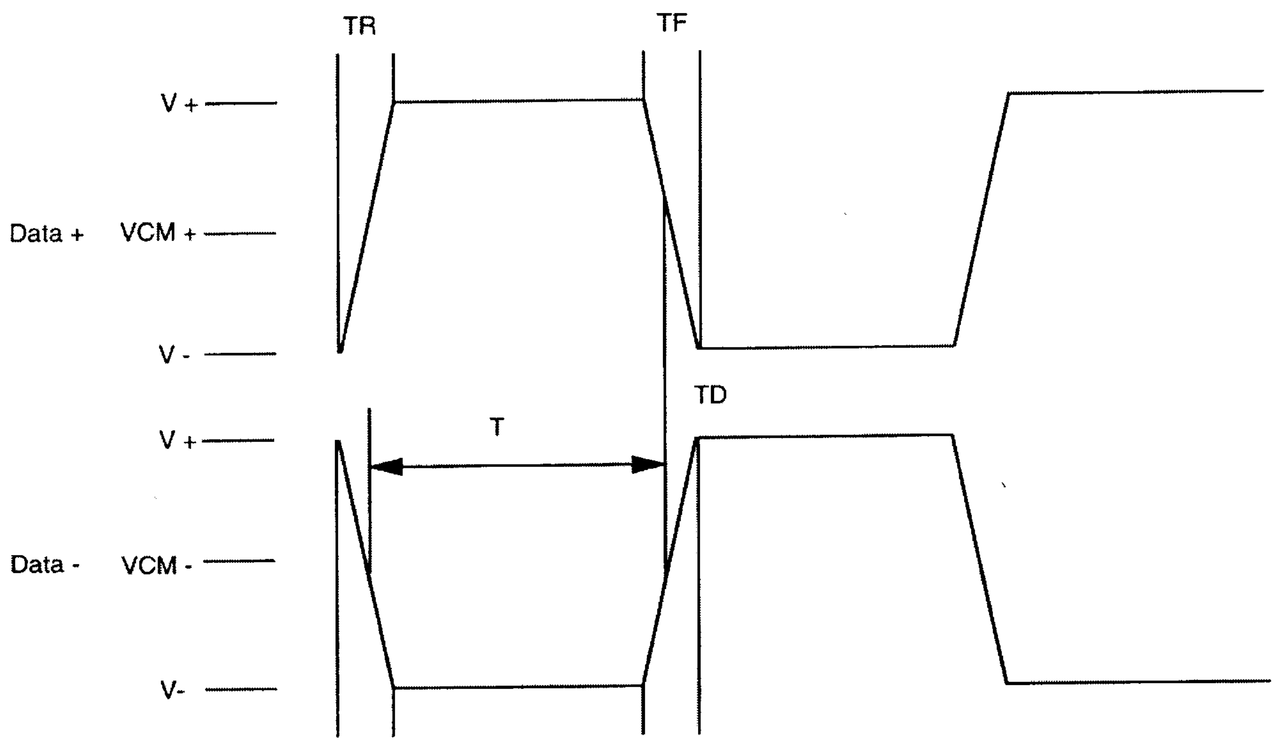


FIGURE 2.57 MEDIUM RATE CUSTOMER INTERFACE

Medium Rate Customer Data



Required: VCM+ = VCM- +/-50MV, Then VCM+ = VCM- = VCM
Required: VCM + 1 volt $\leq$ V + $\leq$ VCM + 2.5V
Required: VCM - 1 volt $\geq$ V - $\geq$ VCM - 2.5V
Required: -3 volts $\leq$ VCM $\leq$ + 3 volts with respect to signal ground
TR $\leq$ TF $\leq$ 1US

For Data + and Data- Lines

T = Baud Period = 1/Baud Rate   Baud Rate = TBD
T = Differential Time Delay = 10 MS Max
Baud Rate Stability $\leq$ 0.1%

FIGURE 2.58 MEDIUM RATE CUSTOMER DATA

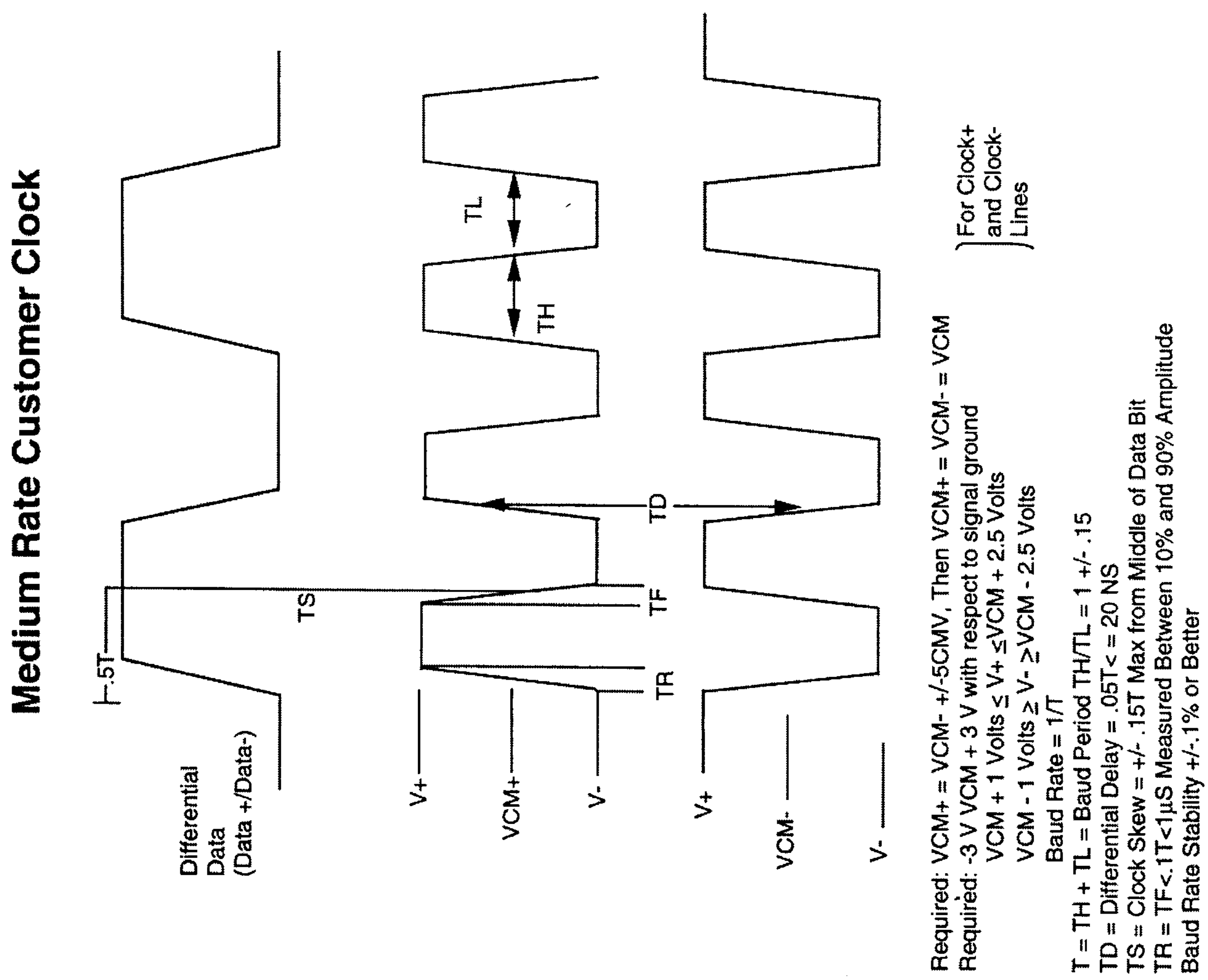


FIGURE 2.59 MEDIUM RATE CUSTOMER CLOCK

2.4.6 Analog Data

One analog data line is provided in each standard interface. This line is sampled at a rate of approximately 15 Hz. Voltages in the range of -0.06 to 5.04 volts are converted to 8-bit values (00 and FF, respectively). Voltages slightly below -0.06 or above 5.04 volts will be transmitted as 00 or FF (i.e., no foldover occurs). An index pulse on a separate wire occurs once per sample and can be used to advance a customer-supplied analog multiplexer to allow multiple parameters to be sampled over the single analog line. Several (typically three) of the multiplexer's inputs should be connected to known fixed voltages (e.g., +5.10, zero, +2.50) to allow the customer's ground equipment to determine synchronization with the returned sample sequence. Analog interfaces are shown in Figure 2.60.

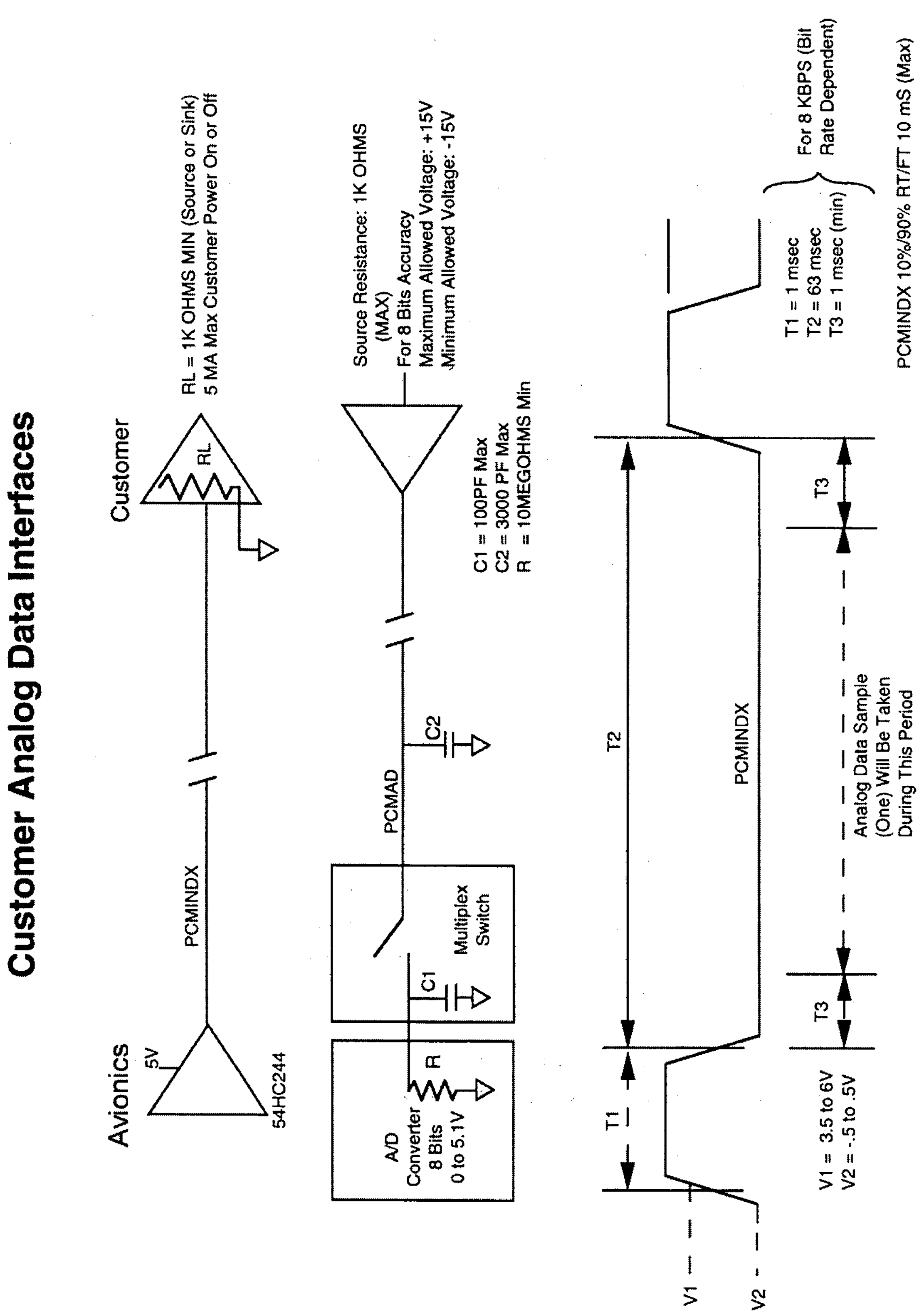


FIGURE 2.60 CUSTOMER ANALOG DATA INTERFACES

2.4.7 Temperature Data

As provided in each interface, three additional analog data lines (Figure 2.33) are sampled at approximately .5 Hz (-0.06 - +5.04v, 8 bits) and are provided with a regulated power source and resistor network. These are intended for connection to YSI 44006 (see Section 2.2.2) thermistors to be supplied by GSFC and installed inside the customer's flight equipment by the customer. These networks and thermistors allow temperatures in the range of -20 to +60 degrees C to be measured without requiring the customer equipment to be operating. If all the thermistor lines are not required for temperatures, they may be used by the customer to measure other parameters such as: canister temperature, bottom plate temperature, canister pressure, and door position (if door is present).

2.4.8 Inter-Range Instrumentation Group, Type B (IRIG-B) MET Signal

Orbiter MET in IRIG-B format will be distributed to each interface. This signal is maintained to within 10 milliseconds (ms) and consists of a 100 Pulse Per Second (PPS) Pulse-Width-Type PCM signal giving days, hours, minutes, and seconds, once each second. In addition, there will be a MET minute signal; Transistor-Transistor Logic (TTL) levels, nominal square wave 1 ppm; edges traceable to MET within 10 ms. The customer timing interface is shown in Figure 2.60. Greenwich Mean Time (GMT) may be used in place of MET on some HH missions.

Real-time data transmitted to customer's GSE can usually be tagged by the customer's software to within 10 seconds. Therefore no time signals may be necessary at the customer's payload if time knowledge to within 10 seconds is adequate. If it is necessary to have time knowledge within the customer's payload, the MET minute signal can be used to reset a customer one-minute clock to 10 milliseconds accuracy. If the customer is using the asynchronous command channel, day-hour-minute-second time may be sent to the customer's payload periodically to update an on-board clock to within 3 seconds. This may be used in conjunction with the above minute pulse to obtain maximum accuracy. The IRIG time signal may also be decoded to obtain day-hour-minute-second time to within 10 milliseconds but is recommended only for existing designs because of the larger number of electronic parts required for decoding.

The signal characteristics of this interface are described in paragraph 8.2.10 of JSC 07700 Vol. XIV Attachment 1 OICD 2-19001) SHUTTLE ORBITER/CARGO STANDARD INTERFACES. This paragraph follows.

> [8.2.10.1.1] GMT (in HH Application, MET). The absolute time data, at any given time during a seven-day mission, shall not deviate by more than +/- 10 milliseconds from the groundstation MET Reference Time Standard and shall be synchronized with the ground MET at certain times during a mission, subject to mission procedural constraints to prevent ring unacceptable time base perturbations. The accuracy of these time updates shall be +/- 5 milliseconds. The Master Timing Unit (MTU) frequency offset and drift rates shall constrain the time error growth rate to a maximum of +/- 10 milliseconds per 24 hours.

The MET output format is modified IRIG-B as shown in Figure 2.62. The electrical interface characteristics are shown in Figure 2.61.

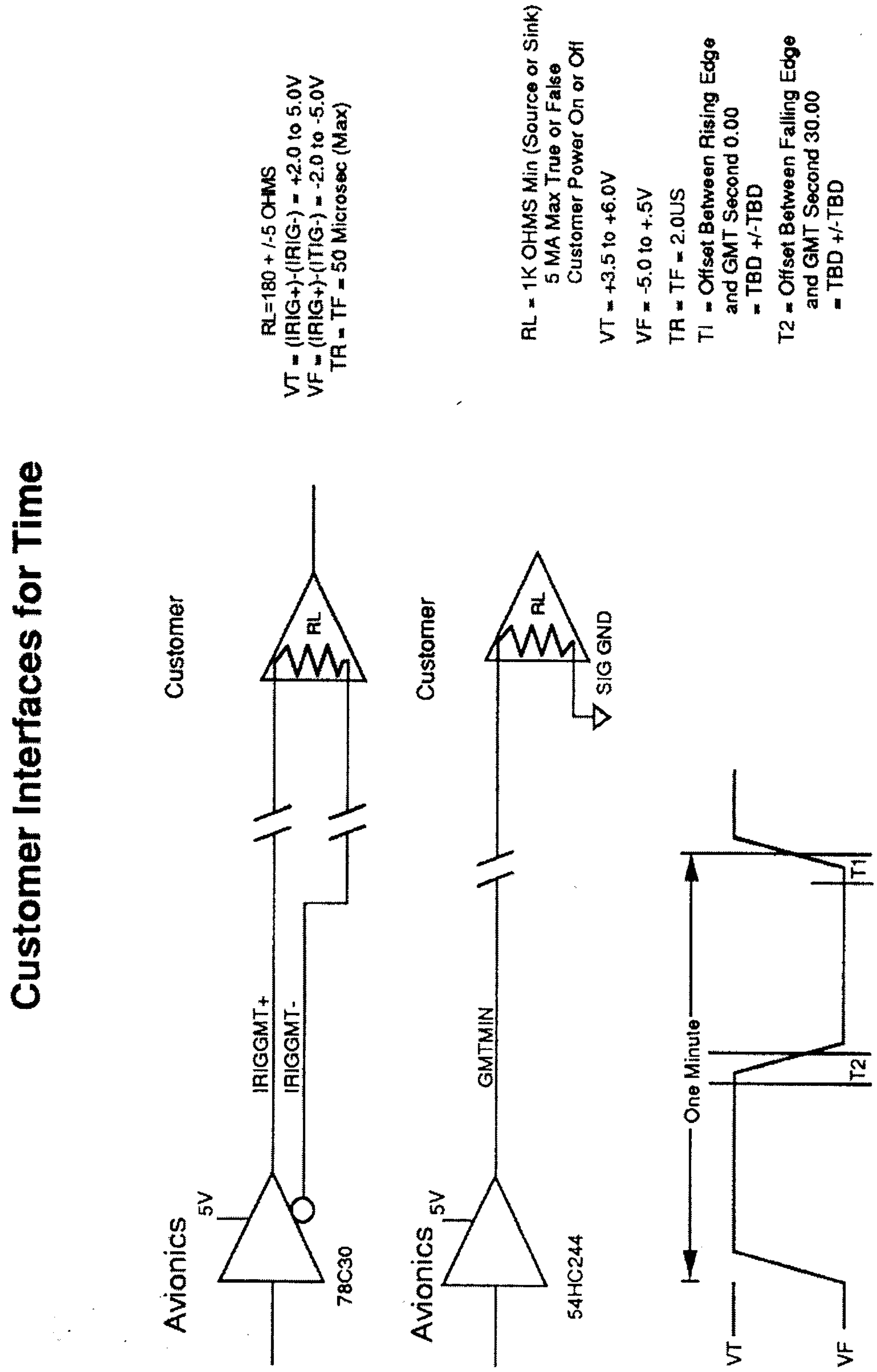


FIGURE 2.61 CUSTOMER INTERFACES FOR TIME

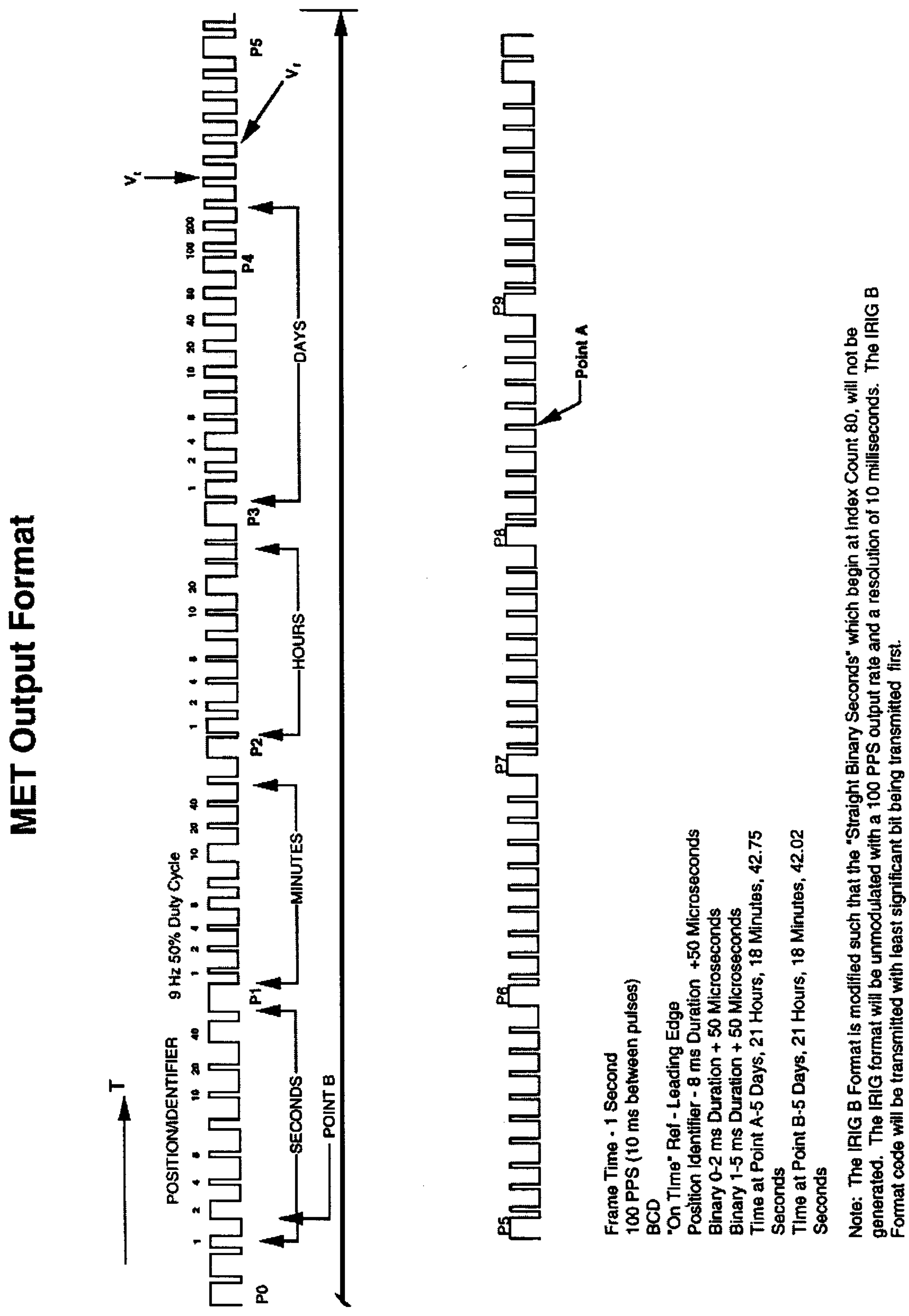


FIGURE 2.62 MET OUTPUT FORMAT

2.4.9 ACCESS/CGSE Interface

Overall communication between the customer's payload and their ground support equipment are shown in Figure 2.63. The ACCESS provides the customer with (1) the command interface between the CGSE and the customer payload, (2) low-rate customer payload data as telemetered by the HH avionics, and (3) Orbiter ancillary data. The ACCESS provides two asynchronous data lines for these purposes.

The Advanced Carrier Customer Equipment Support System (ACCESS) is a Pentium PC-based, networked system that allows customers to receive telemetry from and send commands to their experiment during Integration and Test (I&T) and mission operations. The ACCESS system consists of the User Interface Unit (UIU) and the Carrier Interface Unit (CIU) and the Medium Rate Demultiplexer Unit (MRDU). Figures 2.63 and 2.64 illustrate the Hitchhiker ACCESS system. ACCESS can also provide data displays for each customer and thermal plotting capabilities.

The UIU is the main console for the system operator. Its overall function is to ingest low rate telemetry packets via the network from the CIU and distribute user packets via the ARNET RS232/RS422 ports. It allows the operator to send various directives and commands to control the different UIU and CIU processes as well as control of the HH Carrier. The UIU also allows the operator to view numerous pages that monitor the health and safety for the customer payload, such as the current and temperatures. The UIU also performs hazardous command checks and telemetry limit checking. The UIU is also responsible for ingesting users commands via RS232/RS422 serial ports and sending the command packets to the CIU for output to the carrier.

The CIU is responsible for ingesting low rate telemetry from the HH carrier in the form of minor frames (I&T) or NASCOM blocks (mission), decommutating the data into subcom frames, and creating user data packets for distribution through the UIU to the customer. The CIU is also responsible for transmitting the commands to the avionics in I&T format (ground testing) or NASCOM format (mission operations). The CIU acts as a front end for the UIU.

The MRDU is a stand-alone medium rate processing system that ingests the 2MB composite data stream from the NASA Communications network (NASCOM), demultiplexes the customer medium rate data, and distributes that customer data via an RS422 interface to the CGSE. The MRDU is also responsible for archiving the 2MB composite data stream for use in creating the post-mission customer data products.

The ACCESS also has the capability of providing a real-time Data Display Unit (DDU) for each customer's use during a HH mission. The DDU's are stand-alone Windows-based PC's that display HH avionics health and safety data, as well as thermistor temperatures, customer data streams, and other telemetry and command status information. The pages displayed on the DDU contain the same information used by the ACCESS operators to monitor the HH avionics.

The thermal plotting capability is contained in a stand-alone workstation monitored by a thermal engineer during all HH missions. The system provides real time monitoring and near real time plots of the HH avionics and customer temperatures.

The following sections define the electrical interfaces supported by the ACCESS and the data transferred between the ACCESS and the CGSE.

Hitchhiker/Customer Communications

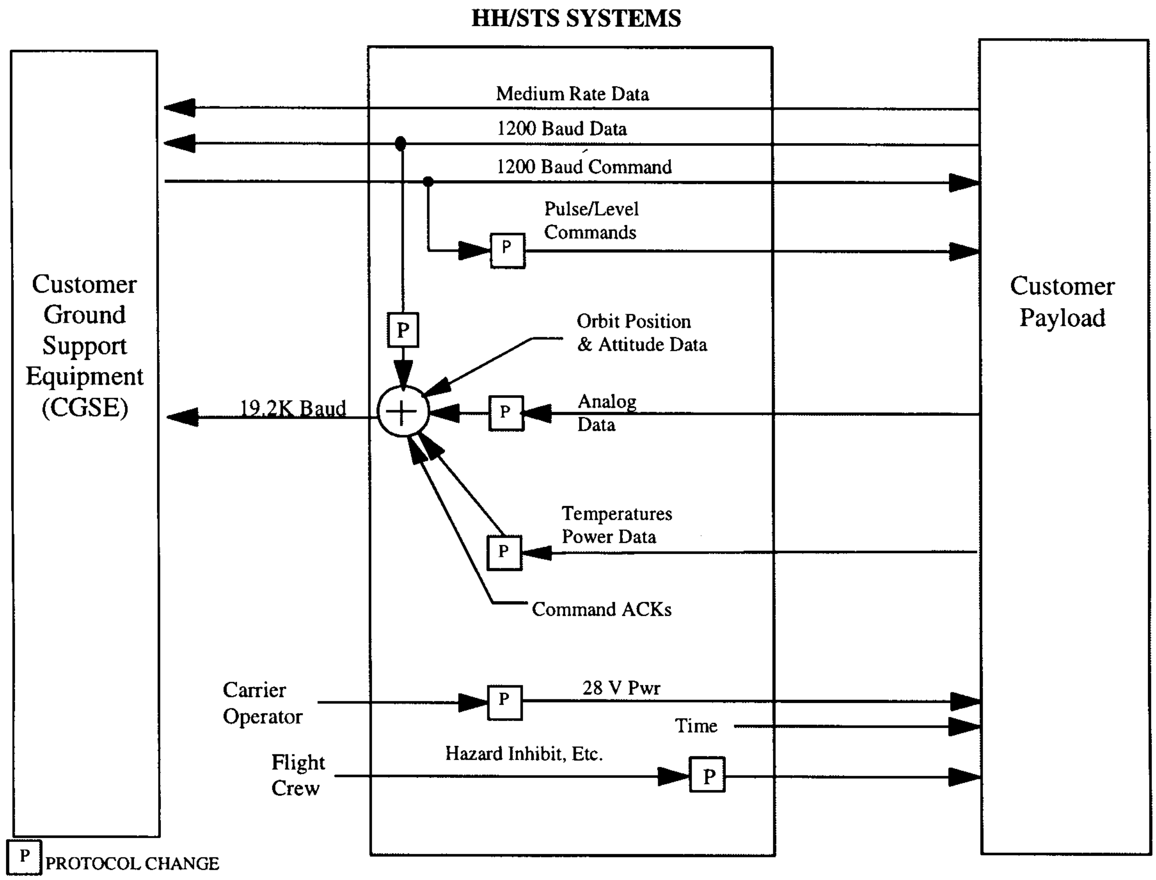


FIGURE 2.63 HITCHHIKER/CUSTOMER COMMUNICATIONS

Advanced Carrier Customer Equipment Support System (ACCESS)

Low Rate Data Processing

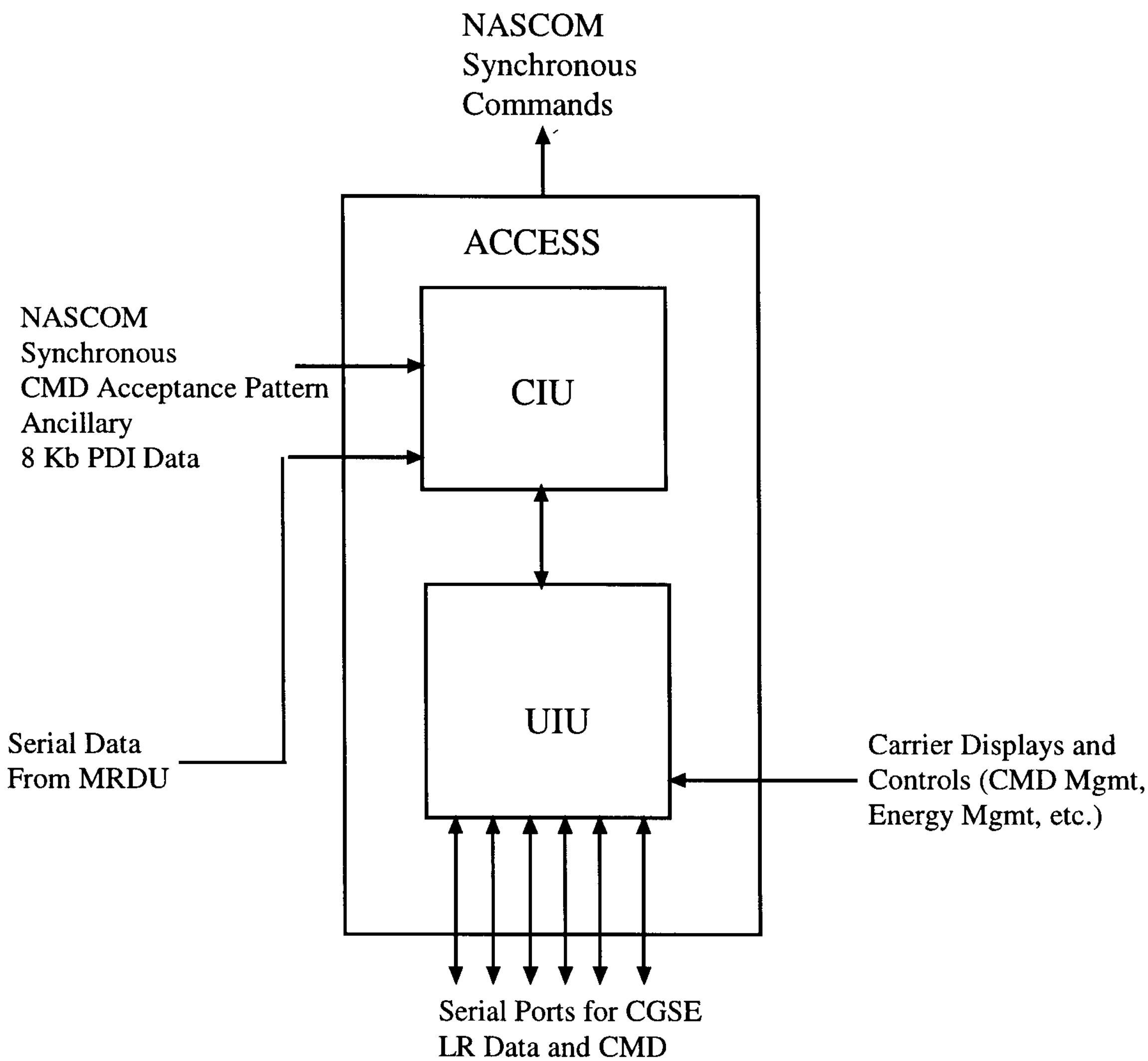


FIGURE 2.64 ACCESS LOW RATE DATA PROCESSING

Advanced Carrier Customer Equipment Support System (ACCESS)
Medium Rate Data Processing Unit (MRDU)

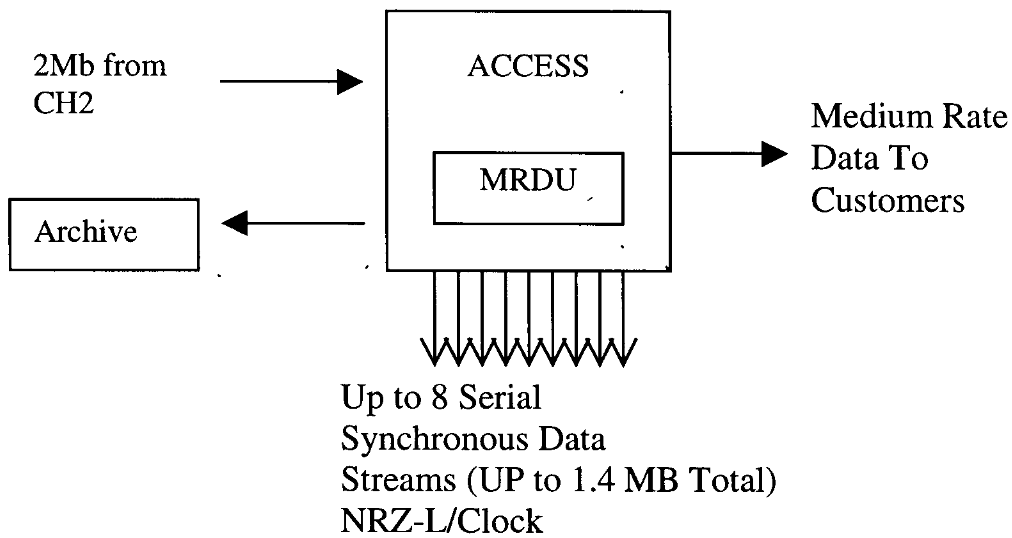


FIGURE 2.65 ACCESS MEDIUM RATE DATA PROCESSING UNIT

2.4.9.1 ACCESS-CGSE Physical Interface Requirements.

The asynchronous interfaces for customer unformatted payload telemetry (type 2) data and command generation are RS-232 or RS-422 compatible. These interfaces are full duplex with an ACCESS receive side for CGSE command messages and an ACCESS send side for transmitting customer data to the customer CGSE. One line (either RS-232 or RS-422) is assigned per customer ID (CID). The default data rate is 1200 baud (see Table 2.9 for additional line rates and information).

The asynchronous interfaces provided for HH ancillary data (type 4), formatted payload data (type 2), Shuttle orbit and attitude data (CAS – type 10), Analog data (type 3), Command Completion status messages (type 5), and Command Link status messages (type 6) are RS-232 compatible. These interfaces are half duplex and are not nominally used for command messages. The default rate is 19200 baud (see Table 2.9 for additional information).

A summary of the RS-232-C and RS-422 lines and their characteristics are presented in Table 2.9. The RS-232-C and RS-422 connector types and pin assignments are shown in Tables 2.10 and 2.11 respectively.

The interface for customer medium rate payload telemetry is RS-422 compatible. One line is assigned per customer ID (CID). The data rate is dependent on the number of customers using the HH avionics medium rate capability up to a combined rate of 1.2 Mb.

The medium rate connectors and pin assignments are shown in Table 2.12. A more detailed explanation of the telemetry and command interfaces are provided in the following sections.

TABLE 2.9 ACCESS - CGSE COMMUNICATIONS LINE

Line #	Line Characteristics	Function	Comments
1	Full Duplex, 1200 Baud, No Echo, 1 Start, 1 Stop, No Parity, RS422 Or RS232	Access Receive Side: CGSE Command Messages Access Send Side: Raw Payload Data From Avionics Asynchronous Send Data Port.	1 Line Per CID
2	Half Duplex, 19.2k Baud, No Echo, 1 Start, 1 Stop, No Parity, 8 Bit Data RS232	Multiplexed Data Messages Of Any Of The Following Types: 2 - Customer Async Data 3 – Customer Analog Data 4 – HH Ancillary Data 5 – Customer Command Completion 6 - Customer Command Link Status 10 - Shuttle Ancillary Data (Orbit/Attitude) 14 - Customer PCM-B Data 15 - Customer PCM-A Data	1 Line Per CID If Utilization Rate Exceeds 75% Of Baud Rate, A Second Line Will Be Required

TABLE 2.10 PIN DESIGNATION FOR RS-232 ASYNCHRONOUS DATA
(ACCESS to CGSE)
Serial Formatted Data
Unformatted Data
Avionics Ancillary Data
STS Orbit/Ancillary Data
Serial Command Messages (CGSE to ACCESS)

PIN Number	Function (Access)
1	Frame Ground (FG)
2	Transmit Data (TD)
3	Received Data (RD)
4-6	N/C
7	Signal Ground (SG)
8-25	N/C

The Serial Interface Circuit will use the "Null Modem" configuration, shown in Figure below.

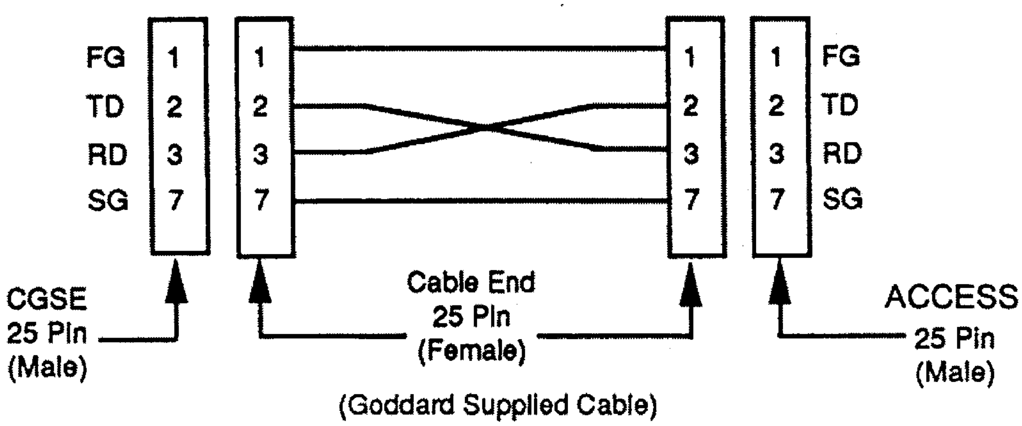


TABLE 2.11 PIN DESIGNATION FOR RS-422 ASYNCHRONOUS DATA
(ACCESS to CGSE)
Serial Formatted Data
Formatted Data
Serial Command Messages (CGSE to ACCESS)

Pin Number	Function	Comments
1	Frame Ground	Connector Type-
2	(+) Transmit Data	25-Pin Male
3	Signal Ground	Suggested Part
4	(-) Transmit Data	Sources
5	Signal Ground	(Male Connector)
6	(+) Receive Data	1. AMPHENOL
7	Signal Ground	P/N 0325PV
8	(-) Receive Data	2. TRW "Cinch"
9	Signal Ground	P/N DB-25P
10-25	N/C	or MIL-SPEC
		M24308/4-3

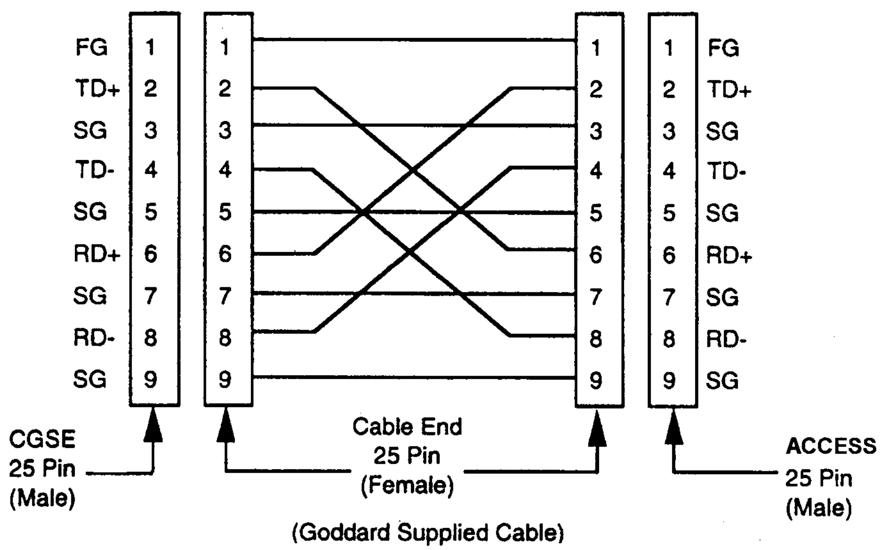


TABLE 2.11 PIN DESIGNATION FOR RS-422 ASYNCHRONOUS DATA
(ACCESS to CGSE)
Serial Formatted Data
Formatted Data
Serial Command Messages (CGSE to ACCESS)

Pin Number	Function	Comments
1	Frame Ground	Connector Type-
2	(+) Transmit Data	25-Pin Male
3	Signal Ground	Suggested Part
4	(-) Transmit Data	Sources
5	Signal Ground	(Male Connector)
6	(+) Receive Data	1. AMPHENOL
7	Signal Ground	P/N 0325PV
8	(-) Receive Data	2. TRW "Cinch"
9	Signal Ground	P/N DB-25P
10-25	N/C	or MIL-SPEC
		M24308/4-3

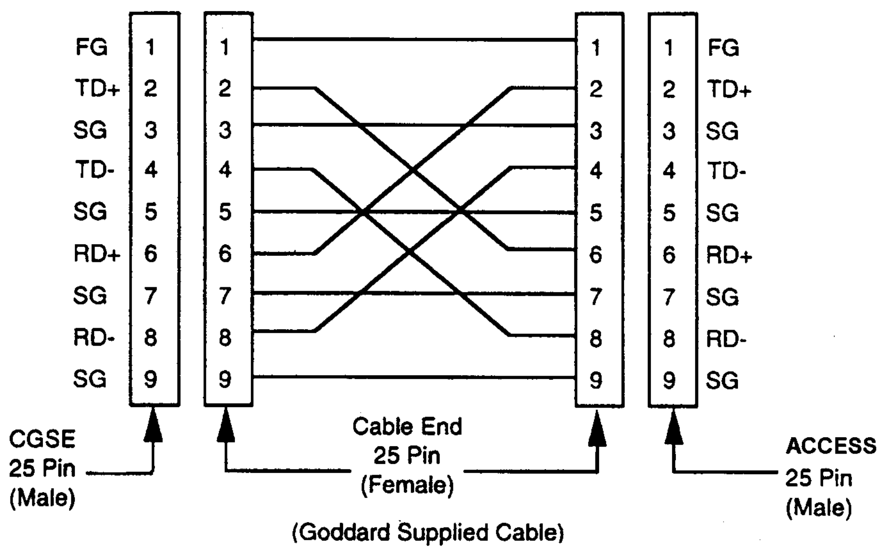
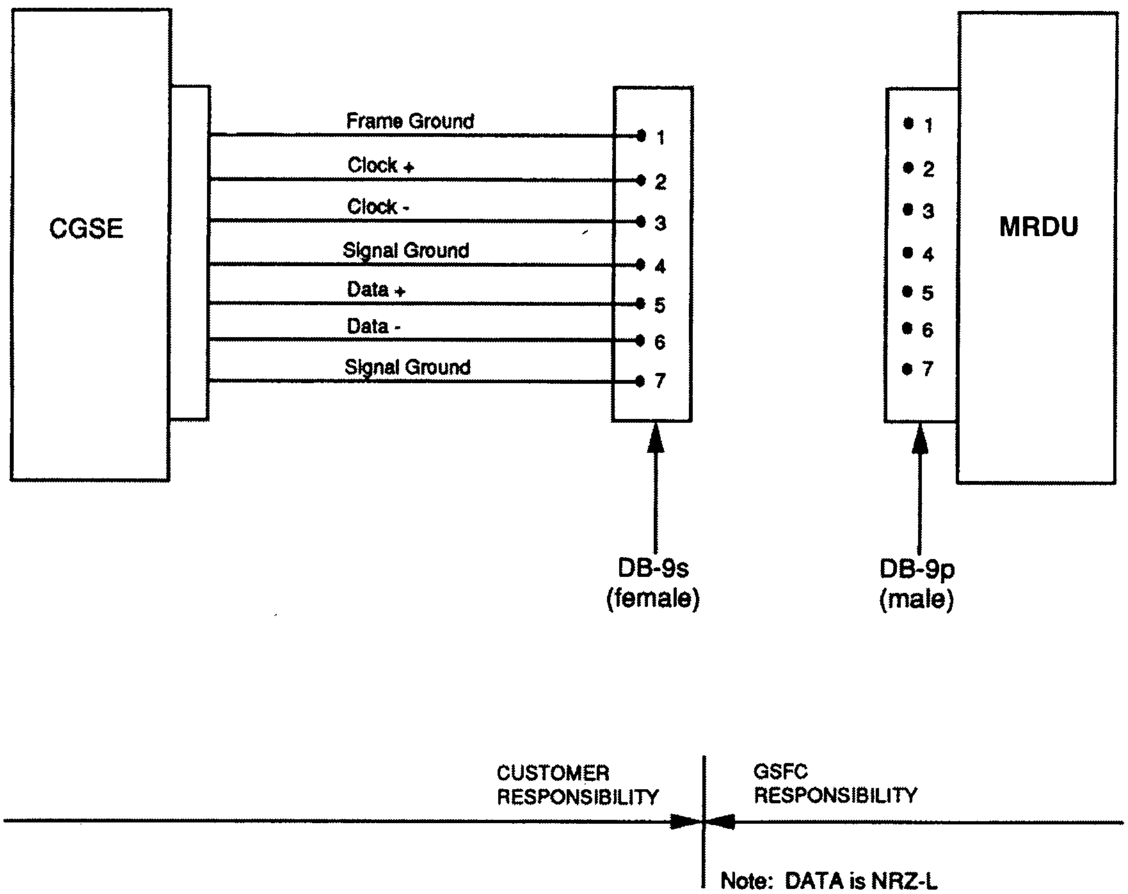


TABLE 2.12 PIN DESIGNATION FOR CUSTOMER RS-422 MEDIUM RATE DATA
Ground Data Interface
(ACCESS to CGSE)



NOTE: Suggested Cable length is 30 feet.

2.4.9.2 ACCESS-CGSE Telemetry Interface

The ACCESS can provide HH avionics telemetry and asynchronous payload telemetry to the CGSE. No data interpretation or conversions are performed by the ACCESS. All data of a given type are transferred in a time-sequential order. The following sub-sections describe the format of the data transferred.

1. Unformatted Customer Payload Asynchronous Downlink Data (Type 2)

The customer will receive the asynchronous payload telemetry in near real-time in a "transparent" manner. The data are bursted to the CGSE over a dedicated 1200-baud asynchronous telemetry/command line (RS-232-C or RS422) without any framing, as they are received by the ACCESS. No attempt is made to synchronize this stream with any other data stream or to maintain the data sampling timing relationship within a stream.

2. Formatted Customer Asynchronous Downlink Payload Data (Type 2)

The ACCESS formatted messages contain a maximum of 120 bytes of payload data and contain the HH time code of the telemetry frame containing the last data byte transmitted within the message. This data message format is shown in Table 2.13. The ACCESS schedules transmission of these blocks upon the filling of the data fields within the message or after one second if the message is not empty. If these messages are multiplexed with other message blocks, the timing between messages is erratic. Note that it is possible to receive a block with "no data bytes" if a sync error is encountered.

The customer will receive the formatted asynchronous payload data in near real time over an ACCESS/CGSE line. The electrical interface is nominally a 19.2 baud RS-232-C data line. The ACCESS will place the payload data into individual messages. No attempt is made to synchronize the data within the messages.

The ACCESS can also send the HH avionics ancillary data, customer energy data, analog data, command acknowledgments, and a subset of the Shuttle orbit and attitude data multiplexed with the formatted asynchronous payload data.

The aggregate data rate of all the multiplexed data (including overhead) must not exceed 75 percent of the data line baud rate. Whenever the data rates are predicted to exceed the 75 percent threshold, another RS-232-C line will be provided. In this case, the assignment of data types transferred over each line will be negotiated with the Project. The user may reconstruct each data stream by grouping data of similar types.

TABLE 2.13 ACCESS FORMATTED ASYNCHRONOUS DATA MESSAGE STRUCTURE

Byte	Bits	Function	Content
1	1-8	Synchronization	E5 (Base 16)
2	1-8	Number of data bytes in message	$0 \leq N \leq 120$
3	1-4	Customer Identification (CID)	$1 \leq CID \leq 8$
3	5-8	Message type	2
4-5	1-8/1-8	Binary day of MET from Avionics PCM frame containing last payload data byte (DD)	$0 \leq DD \leq 366$
6-9	1-8/1-8	Milliseconds of day from Avionics PCM frame containing last payload data byte. Treated as a 32-bit integer (M)	$0 \leq M \leq 86399999$
10	1	Avionics minor frame sync loss indicator 1 = sync loss during data collection	0/1
10	2	MCU frame sync loss indicator 1 = sync loss during data collection	0/1
10	3	MCU encountered data overrun if set to 1	0/1
10	4	MCU encountered parity error if set to 1	0/1
10	5-8	Spare	0'S
10+N	1-8	Payload data	0-255
11+N	1-8	Exclusive OR of bytes 2 through (N+10)	0-255

3. Customer Analog Data (Type 3)

The customer may receive data from its analog channel assigned by the HH mission. The ACCESS formats the data into message blocks as shown in Table 2.14. The data are tagged with the HH time code (MET) of the minor frame containing the last byte of user data transmitted within the message. No attempt is made to synchronize the data within the sequence of analog samples. This message is scheduled for transmission to the CGSE every HH major frame. It is multiplexed with other ancillary and command acknowledgment messages, hence the timing between the messages is erratic. However, the time for messages of the same time is in ascending order.

TABLE 2.14 ACCESS FORMATTED PAYLOAD ANALOG DATA STRUCTURE

Byte	Bits	Function	Value
1	1-8	Synchronization	E5(Base 16)
2	1-8	Number of data bytes in message	32
3	1-4	Customer Identification (CID)	$1 \leq CID \leq 8$
3	5-8	Message type	3
4-5	1-8/1-8	Binary day of year from Avionics PCM frame containing last byte of multiplexer data transferred (DD)	$0 \leq DD \leq 366$
6-9	1-8/1-8/ 1-8/1-8	Milliseconds of day from Avionics PCM frame containing last byte of analog data transferred (M)	$0 \leq M \leq 86399999$
10	1	Avionics minor frame sync loss during data collection if set	0/1
10	2-8	Spare	0
11-42	1-8	Analog data	0-255
43	1-8	Exclusive OR of bytes 2-42	0-255

4. HH Ancillary Data Message (Type 4)

The ACCESS will provide HH avionics ancillary data messages which contain information such as the payload temperatures, relay states, current load, user analog data, and energy usage. The frequency and content of this message is dependent upon the mission-unique HH telemetry format. Currently, the message is transmitted approximately once every 4 seconds assuming a nominal 8kb/sec telemetry rate. The format of the HH ancillary data messages is defined in Table 2.15. The time field is the HH time code of the minor frame from which the last data byte was sampled.

TABLE 2.15 ACCESS ANCILLARY DATA MESSAGE STRUCTURE

Byte	Bits	Function	Content
1	1-8	Synchronization	E5 (Base 16)
2	1-8	Number of data bytes in message	10
3	1-4	Customer Identification (CID)	$1 \leq \text{CID} \leq 8$
3	5-8	Message type	4
4-5	1-8/1-8	Binary day of year	$0 \leq \text{DD} \leq 366$
6-9	1-8/1-8/ 1-8/1-8	Milliseconds of day	$0 \leq \text{M} \leq 86399999$
10	1	HH minor frame sync loss indicator (1=Loss)	0/1
10	2	MCU sync loss indicator (1=Loss)	0/1
10	3	Avionics analog channel sync loss (1=Loss)	0/1
10	4-8	Spare	0
11	1-8	Current drawn by user in counts (as telemetered)	0-255
12	1-8	Relay status as telemetered	0-255
13	1-8	Heater bus status	0-255
14	1-8	Thermistor #1 reading in counts	0-255
15	1-8	Thermistor #2 reading in counts	0-255
16	1-8	Thermistor #3 reading in counts	0-255
17	1-8	Energy usage as computed by MCU in counts (Sample 1)	0-255
18	1-8	Bus voltage as sampled by MCU in counts (sample 1)	0-255
19	1-8	Energy usage as computed by MCU in counts (sample 2)	0-255
20	1-8	Bus voltage as sampled by MCU in counts (sample 2)	0-255
21	1-8	Exclusive OR of bytes 2-20	0-255

5. Shuttle Orbit and Attitude Data Messages (Type 10)

The customer may receive the Shuttle orbit and attitude parameters as they are received by the ACCESS from the Calibrated Ancillary System (CAS) at the Johnson Space Center (JSC). No attempt is made to convert the data values. The time field is contained in the Shuttle ancillary data block received from the CAS. Table 2.16 depicts the default format and content of the message. The frequency of the message is approximately once a second. The customer may negotiate with the Project for the inclusion of other data found in the Shuttle ancillary data block.

Algorithms for converting the quaternions in these messages to RA/DEC of the Z axis or orbiter R,P,Y angles are given in Appendix G.

TABLE 2.16 SHUTTLE ORBIT AND ATTITUDE DATA MESSAGE STRUCTURE

Byte	Bits	Function	Value
1	1-8	Synchronization	E5 (Base 16)
2	1-8	Number of data bytes in message, excluding header and checksum	92
3	1-4	Customer Identification (CID)	$1 \leq \text{CID} \leq 8$
3	5-8	Message type	10
4-5	1-8/1-8	Binary day of year computed from Primary Source MET	$0 \leq \text{DD} \leq 366$
6-9	1-8/1-8/ 1-8/1-8	Milliseconds of day computed from Primary Source MET	$0 \leq \text{M} \leq 86399999$
10	Spare		
11-18	All	X-Component of current Shuttle position vector in IBM floating point. M50 coordinate system.	
19-26	All	Y component of current Shuttle position vector IBM floating point. M50 coordinate system.	
27-34	All	Z component of current Shuttle position vector in IBM floating point M50 coordinate system.	
35-38	All	X component of velocity vector in IBM floating point. M50 coordinate system.	
39-42	All	Y-component of velocity vector in IBM floating point. M50 coordinate system.	
43-46	All	Z component of velocity vector in IBM floating point. M50 coordinate system.	

TABLE 2.16 CONTINUED

47-54	All	Time Tag associated with current state in IBM floating point.
55-58	All	M50 to measured body quaternion element 1 in IBM floating point
59-62	All	M50 to measured body quaternion element 2 in IBM floating point
63-66	All	M50 to measured body quaternion element 3 in IBM floating point
67-70	All	M50 to measured body quaternion element 4 in IBM floating point
71-74	All	M50 WRT LVLH quaternion element 1 in IBM floating point
75-78	All	M50 WRT LVLH quaternion element 2 in IBM floating point
79-82	All	M50 WRT LVLH quaternion element 3 in IBM floating point
83-86	All	M50 WRT LVLH Quaternion Element 4 in IBM floating point
87-102	All	Vernier Jet Data
103	1-8	Exclusive OR of bytes 2-102

TABLE 2.16 CONTINUED

VERNIER JET DATA

Bytes 87-102

Up to 16 Samples of Orbiter Vernier Thruster Data in Time Sequence

Bit 1 = 0	Valid Sample
Bit 1 = 1	Fill (No valid sample)

Bit 2 Spare

Bits 3-8 Vernier Jet Data
1 = Jet Firing
0 = Jet Not Firing

BIT	JET	POSITION	PLUME DIRECTION
3	F5L	FWD-Left	Down/Left
4	F5R	FWD- Right	Down/Right
5	L5D	AFT-Left	Down
6	L5L	AFT-Left	Left
7	R5R	AFT-Right	Right
8	R5D	AFT-Right	Down

TABLE 2.16 CONTINUED

VERNIER JET DATA

Bytes 87-102

Up to 16 Samples of Orbiter Vernier Thruster Data in Time Sequence

Bit 1 = 0	Valid Sample
Bit 1 = 1	Fill (No valid sample)

Bit 2 Spare

Bits 3-8 Vernier Jet Data
1 = Jet Firing
0 = Jet Not Firing

BIT	JET	POSITION	PLUME DIRECTION
3	F5L	FWD-Left	Down/Left
4	F5R	FWD- Right	Down/Right
5	L5D	AFT-Left	Down
6	L5L	AFT-Left	Left
7	R5R	AFT-Right	Right
8	R5D	AFT-Right	Down

2.4.9.3 ACCESS-CGSE Command Interfaces

Messages are exchanged between the ACCESS and CGSE for payload commanding and command acknowledgment.

The ACCESS UIU will accept commands from the CGSE over a 1200 baud RS-232-C or RS-422 interface. These commands will be screened by the ACCESS for criticality, then transferred to the ACCESS CIU via the LAN. Once a customer's command is received at the CIU, it is placed in a command block, encoded in the proper format (NASCOM or I&T) and placed into an uplink command buffer, then transmitted. The CIU will verify that the command block was accepted by the HH avionics. A new command block will not be transmitted until a previously transmitted command block is verified by the HH avionics in telemetry. Commands that are not verified within a timely manner (nominally 5 seconds for I&T, and 15 seconds during mission operations) by the HH avionics will be retransmitted by the ACCESS operators. The command will not be released from the ACCESS buffer until a verification has been received from the avionics. ACCESS, however, does not monitor the telemetry to determine if the customer payload responded to the commands.

Customer CGSE's are connected to the ACCESS via the Serial Port Interfaces referenced in Figure 2.63. This places some limitations on user command thru-put, especially for long "back to back" experiment command strings.

In reference to the HH Command Flow, the following three elements apply:

1. The presence of a 1200-baud ACCESS line does not mean that the user can continuously pump commands at this rate. The maximum command string length is 119 bytes. User minimum Delay Time (DT) between command strings sent by its CGSE to the ACCESS is:

   DT = (Number of active command lines) * (400 milliseconds).

2. The ACCESS UIU uses message queues for transferring user commands to the ACCESS CIU via the LAN. It takes the UIU 400 milliseconds to encode the user input command for transfer it to the CIU. It will take twice as long, on average, to process two user input buffers. If a user does not enforce a delay of DT milliseconds between long command strings, an overflow can occur causing customer commands to be lost.

Command string staging is of significant overhead for the ACCESS. Suggested average separation between long strings of Universal Asynchronous Receiver Transmitter (UART) commands with two active command lines is 800 milliseconds.

The user is advised to hold its long command strings in its own CGSE for DT time rather than using the ACCESS to stage its long command strings.

3. Note that the ACCESS "round-robin" prioritization of users can improve the ACCESS processing of long and short command strings generated by two concurrent users.

2.4.9.4 ACCESS Command Acknowledgment (ACKS) Messages (Types 5/6)

These messages are multiplexed with the HH system ancillary data messages, Shuttle orbit and attitude data messages, etc. All messages are optional. These messages are transmitted from the ACCESS to the CGSE on the 19.2k baud link. The time in these two messages is the ACCESS computer GMT time when the message was generated.

1. Command Completion Status (Type 5)

After transmission by the ACCESS, the ACCESS issues an optional command acknowledgment message to the CGSE indicating the number of commands successfully transmitted to the HH avionics. Upon receipt of this message, the CGSE may issue another set of commands. If the CGSE does not opt for the command completion message, the CGSE should verify the receipt of the commands by the payload prior to transmitting more commands. Failure to do so may result in the loss of commands because the command link is slower than the aggregate command rate of all the users. In fact, transmission delays of 10-20 seconds may be common in operations because of additional delay in the networks and MCC. The format of this message is shown in Table 2.17.

TABLE 2.17 ACCESS COMMAND COMPLETION STATUS MESSAGE STRUCTURE

Byte	Bits	Function	Value
1	1-8	Synchronization	E5 (Base 16)
2	2-8	Number of data bytes in the message, excluding header and checksum	2
3	1-4	Customer Identification (CID)	$1 \leq CID \leq 8$
3	5-8	Message type	5
4-5	1-8/1-8	Binary day of year	$1 \leq DD \leq 366$ (Note 1)
6-9	1-8/1-8/ 1-8/1-8	Millisecond time of day	$0 \leq M \leq 86399999$
10	1-8	Spare	0
11	1-8	Number of commands transmitted	
12	1-8	Number of commands accepted by SPOC	
13	1-8	Exclusive OR of bytes 2-12	0-255

Note 1: This time is the ACCESS computer GMT time.

2. Data Link Status (Type 6)

The ACCESS will originate messages if errors are detected in the command data link between the ACCESS and the CGSE. The messages indicate the error and the number of commands rejected by the ACCESS because of the error. The format of this message is shown in Table 2.18.

TABLE 2.18 ACCESS DATA LINK STATUS MESSAGE STRUCTURE

Byte	Bits	Function	Value
1	1-8	Synchronization	E5 (Base 16)
2	2-8	Number of data bytes in message, from bytes 11 to end not including check sum	2
3	1-4	Customer Identification (CID)	$1 \leq CID \leq 8$
3	5-8	Message Type	6
4-5	1-8/1-8	Binary day of year	$1 \leq DD \leq 366$ (Note 1)
6-9	1-8/1-8/ 1-8/1-8	Millisecond time of day (M)	$0 \leq M \leq 8639999$
10	1-8	Spare	0
11	1-8	Number of command bytes accepted or rejected	$1 \leq M \leq 120$
12	1-8	Status indicator (no bits set = received CMD without errors)	
	Bit #1	- CGSE shipped too many bytes in command message	
	Bit #2	- Parity error in transmission between CGSE-ACCESS	
	Bit #3	- Data overrun	
	Bit #4	- Framing Error	
	Bit #5	- Invalid CID	
	Bit #6	- Checksum Error	
	1-8	Exclusive OR of bytes 2 through 12	0-255

Note 1: This time is the ACCESS computer GMT time.

2.4.10 Crew Control

The Crew Control system provides a second method (independent of the ground command system) for controlling the flow of power to the customer payloads and, thus, ensures that power could be removed from the payload even in the event of any single failure. Since two independent commands (crew and ground) are required to apply power to a customer payload, two inhibits are present to prevent a hazardous payload function from occurring during ascent or descent. Additional crew control functions can be used to inhibit a hazardous payload function during on-orbit operations.

Crew Control of the carrier power system (see Figure 2.34) is implemented using the first two switches S1 and S2 (DS1 and DS2 indicate the state of S1 and S2) of the SPASP or normally the first two switches of the SSP (see Figure 2.68). The carrier can be assigned to either half of the SSP and if assigned to the other half, S13 and S14 (DS13 and DS14 indicate the state of S13 and S14) would be used. The remaining switches can be assigned to a customer function with a negotiated electrical interface. Switch panel control is normally provided only to inhibit a hazardous function or provide a crew controlled function which must be synchronized with some other crew activity such as Orbiter attitude control. The use of the SPASP or SSP is determined by NASA based on the STS manifesting rules. The available switch and indicator characteristics are shown in Figure 2.69. The SSP cargo switching and fusing interface schematic is shown in Figure 2.70 (sheet 1 & 2).

2.4.11 Undedicated Connections in Standard Interface

Some Twisted Shielded Pair (TSP) and single wires in each interface are undedicated and may be connected by mission unique jumper plugs to the following:

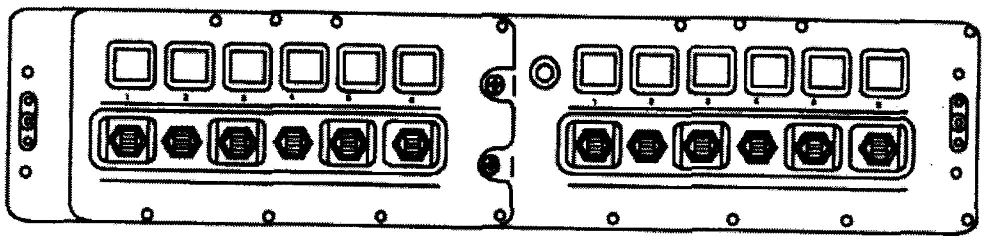
1. Crew Control (Switch Panel)

2. Undedicated wires in a second standard interface port assigned to the same customer.

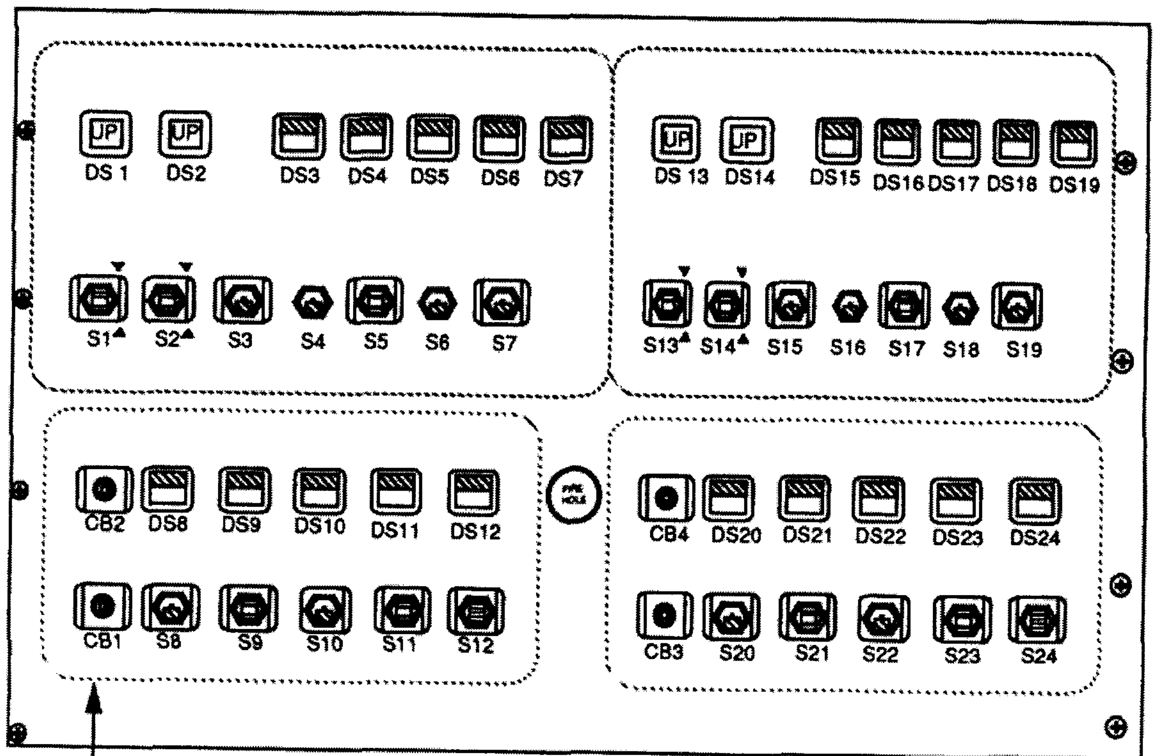
3. Other function as negotiated.

Use of the special connections may result in conflicts between customer payloads on the same flight and may therefore reduce manifesting possibilities and flight opportunities for each customer.

Switch Panels



SMALL PAYLOAD ACCOMMODATION SWITCH PANEL (SPASP)
S1, S2, DS1, DS2- RESERVED FOR CARRIER USE

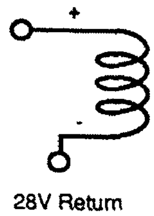


MARKING OF OVERLAYS TO BE DONE BY NSTS PER INDIVIDUAL CUSTOMER REQUIREMENTS.
(OVERLAY WILL COVER COMPONENT DESIGNATORS.)

STANDARD SWITCH PANEL (SSP)
S1, S2, DS1, DS2 OR S13, S14, DS13, DS14 RESERVED FOR CARRIER USE

FIGURE 2.65 SWITCH PANELS

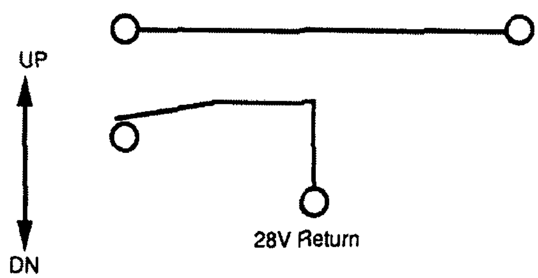
SPASP or SSP Switch and Indicator Characteristics



Coil Resistance
28.0 ± 3 K Ω

On = Gray = 18 to 32 VDC
Off = Stripes = 0 to 5 VDC

SPASP or SSP Mechanical Indicator



SPASP Switch (TYP 6 Places)

Resistance: 5 Ω MAX
Maximum Current: 1 AMP (dc only)
Minimum Current required to drive indicator:30 ma
Maximum Voltage: 32 VDC
Total available for customers: 4 (SPA), 10 (SMC)

FIGURE 2.66 SPASP OR SSP SWITCH AND INDICATOR CHARACTERISTICS

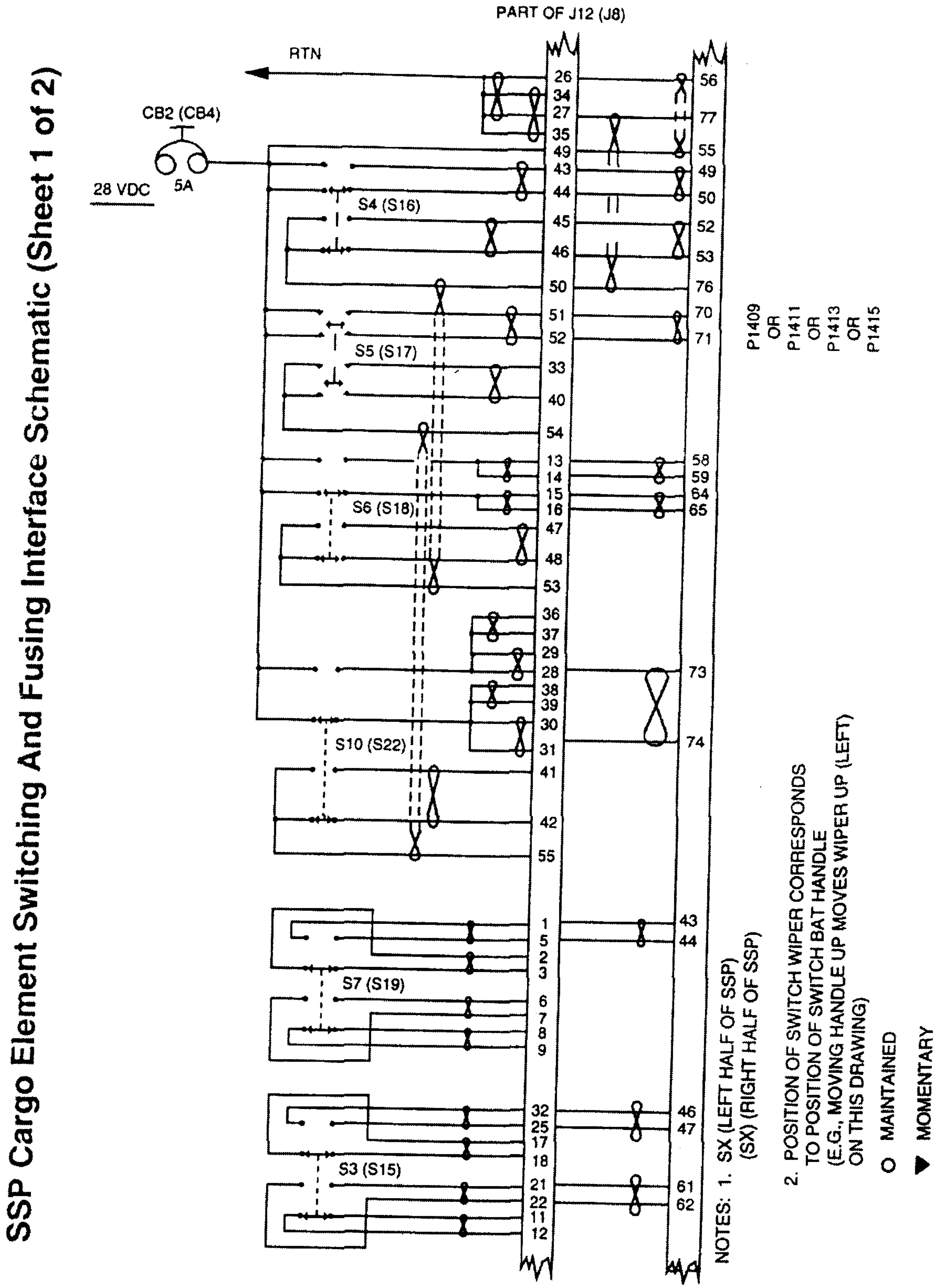


FIGURE 2.67 SSP CARGO ELEMENT SWITCHING AND FUSING INTERFACE SCHEMATIC (1OF 2)

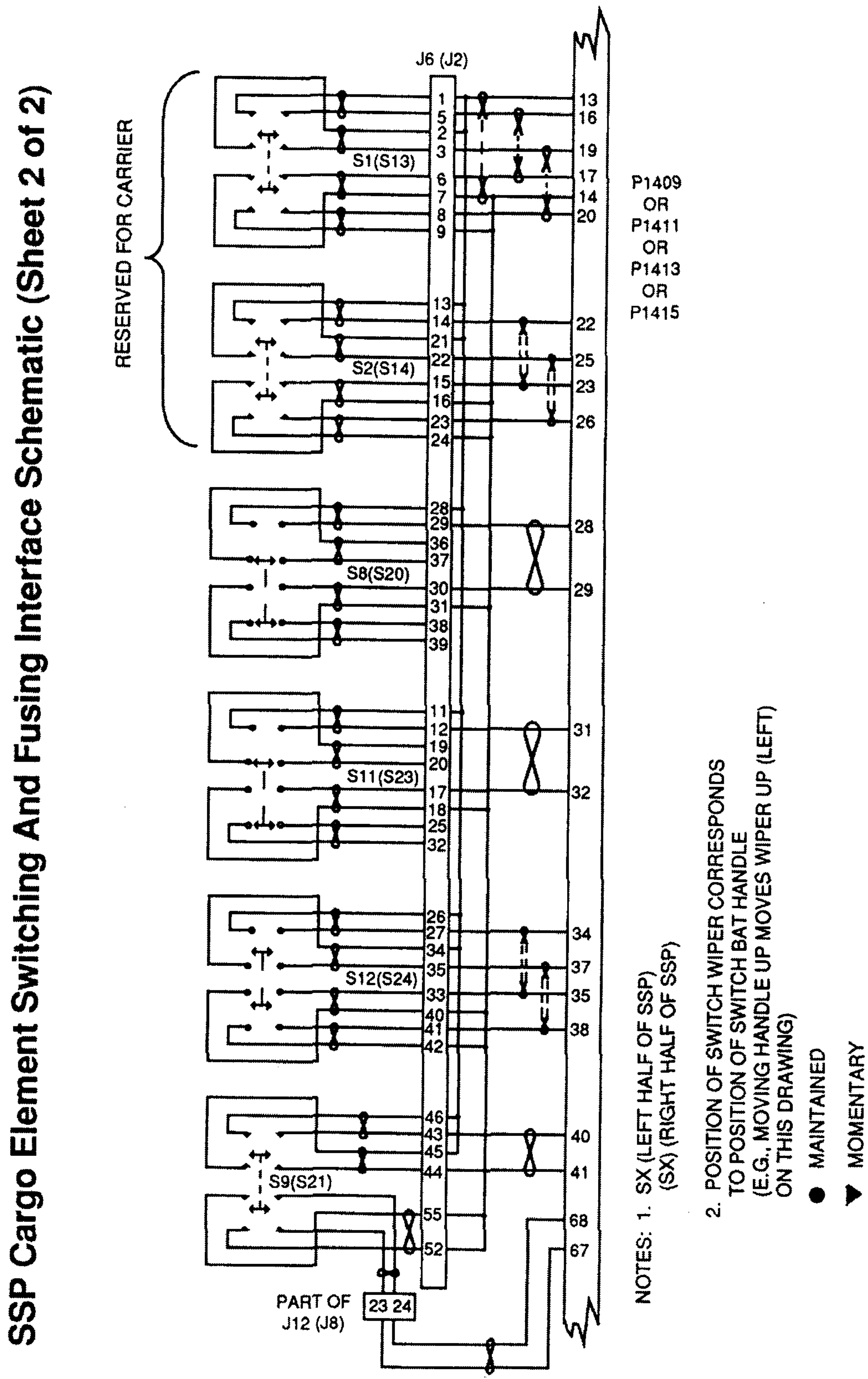


FIGURE 2.68 SSP CARGO ELEMENT SWITCHING AND FUSING INTERFACE SCHEMATIC (2 OF 2)

2.4.12 Orbiter CCTV Interface

A special interface can be provided to allow the display of a customer payload generated TV signal in the crew cabin. This signal can also be recorded on-board or transmitted to the ground. The signals are standard National Television Standard Committee (NTSC) (EIA RS-170/RS-330) color or black and white television signals transmitted on a differential interface. Details of the CCTV interfaces and services can be provided by the project office.

2.4.13 Hitchhiker Video Interface Unit

The Hitchhiker Video Interface Unit (HVIU) is Hitchhiker-provided. Video can be accommodated from eight separate customer signal ports, one at a time. Switching of HVIU channels is commanded via ACCESS. The HVIU produces a differential signal output to the orbiter CCTV interface.

Customer video input to the HVIU shall be an unbalanced, 75-ohm interface and shall conform to RS-170 and RS-330 specifications. Shield shall be tied to frame ground at the customer side; the video signal lines shall be isolated from frame ground by at least 1 Mohm. Therefore, use of commercially available devices which tie signal ground to chassis should be avoided.

During the mission, availability of real-time video telemetry depends on orbiter support of payload CCTV and cannot be guaranteed. However, payload video can be recorded via the orbiter recorders and replayed at a later time during the mission or provided post-mission. Therefore, customers whose video is critical to their experiment are advised to consider incorporating recording capability in their hardware design.

2.5 Hitchhiker-JR (HH-J)

2.5.1 Hitchhiker-JR Overview

The HH-J carrier provides mechanical and electrical interfaces similar to the existing GAS carrier which has been used in the past to carry Shuttle secondary payloads. Following availability of the new carrier, the GAS carrier will not be used for secondary payloads.

The new avionics system (Figures 2.72 - 2.74) provides for better monitoring of carrier functions and can provide improved monitoring and power services for customer equipment if desired.

The HH-J carrier system consists of a canister (with or without a motorized door) equipped with a HH Remote Interface Unit (HRIU). The HRIU communicates via a control line with a Payload and General Support Computer (PGSC) in the crew cabin. The PGSC is a lap top class personal computer and contains payload unique software provided by SSPP.

The HH-J avionics is operated from Orbiter power unlike the GAS avionics which is battery operated. Orbiter power may also be used for heaters and can be used to operate customer equipment if certain restrictions are met. Customer equipment may also be operated from customer supplied batteries if desired.

During flight operations, the crew controls HH-J and GAS payloads using a menu type control and display interface on the PGSC. Unlike the avionics used with GAS, the HRIU reports carrier status information for display to the crew. The status information includes canister temperature